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The effects of exchange rates in sawnwood exports from Finland and Sweden during the EMU regime

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Tiivistelmä — Referat — Abstract

Forest industries of many forest-rich Nordic nations have traditionally been highly export oriented, where domestic demand is not sufficient to guarantee the existing production capacity. Under these circumstances the exchange rate, the value of the domestic currency relative to that of the trading partners, becomes then one of the most important macroeconomic considerations. In the short run it determines the profitability and competitiveness, and thus each firm's survival. In the long run, firms may e.g. hedge against unfavourable currency fluctuations or anticipate future currency developments and stipulate them in their long-term sales contracts. Firms also have the possibility to act strategically by absorbing some or all of a currency change in export prices and this way affecting traded quantities. Although theoretical contributions to the literature fail to conclusively validate this hypothesis and the results of empirical estimations are widely mixed, studies concerning forest products trade have often found evidence of exchange rate effects on traded quantities.

Previous studies concerning Finnish forest product exports have reported the use of exchange rate changes to alter prices in the buyer's currency, especially as a consequence of deliberate currency fixing. For example devaluations, often used to downsize the effect of a rising domestic cost level, have increased the price competitiveness and export quantities of Finnish forest industry firms. Realization of the third phase of the European Economic and Monetary Union (EMU) on the beginning of 1999 merged the participating countries' currencies into the euro at an irrevocable fixed rate, which then eliminated the possibility to independently realign the currency value. Moreover, exchange rate effects, and hence exchange rate risks, have exclusively been vanished from intra-EMU trade. This has meant the opening of a whole new market for many small open economies. At the same time, a change in the business environment could have caused severe adaptation problems to some Finnish forest industry firms.

The aim of the present study is to examine the effects of Finland's EMU participation on its sawnwood exports to the main export markets in United Kingdom and Germany. As Finland's most important competitor Sweden decided to remain outside the monetary union, it was chosen to serve as a reference point for the possible effects the loss of an independent monetary policy has had. Weakening of the krone against the euro for the past years has brought additional interest on the topic. The emphasis is on studying relative prices and its effects on traded quantities through the long-run exchange rate pass-through phenomenon for the period 1995-2008. The empirical estimation is carried out by applying Johansen's cointegration method for the separate partial equilibrium model systems, for each bilateral trade of Finland and Sweden to both destination markets.

The results give evidence that Finnish sawnwood exports have been affected to a great extent by currency movements. Depreciations of the euro have boosted export demand, whereas appreciations have, in turn, dampened imports from Finland. The pricing strategy exploited by Swedish exporters has been somewhat opposite to Finnish exporters'. This has meant both a more stable price for Swedish sawnwood importers and export demand faced by Swedish exporters. These findings further suggest only minor negative effects of Swedish krone depreciations on Finnish sawnwood firms' price competitiveness. Nevertheless, Swedish exporters have been able to achieve higher profits, which seems to have been an important consideration behind some recent shifts of production from Finland to Sweden.

Avainsanat — Nyckelord — Keywords

EMU, exchange rate, export demand, Johansen's cointegration method, pass-through, sawnwood price

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Tiivistelmä — Referat — Abstract

Metsäteollisuudet monissa metsävarannoiltaan rikkaissa pohjoismaissa ovat perinteisesti olleet hyvin vientisuuntautuneita, joissa kotimainen kysyntä ei riitä kattamaan olemassa olevaa tuotantokapasiteettia. Näissä oloissa valuuttakurssi, kotimaan valuutan arvo suhteessa kauppakumppanimaan valuutan arvoon, muodostuu yhdeksi tärkeimmäksi huomioon otettavaksi makroekonomiseksi tekijäksi. Valuuttakurssimuutokset näkyvät yrityksen kannattavuudessa ja kilpailukyvyssä ja näin ollen myös määrittelee kunkin viejän selviytymisen lyhyellä aikavälillä. Pidemmällä aikavälillä yritykset voivat esimerkiksi suojautua epäedullista valuuttakurssikehitystä vastaan tai ottaa huomioon ennustetun kehityksen pitkäaikaisissa myyntisopimuksissa. Viejäyritykset voivat myös toimia strategisesti absorboimalla osan tai koko valuuttakurssimuutoksen vientihintaan ja näin ollen vaikuttaa vaihdetun tavaran määrään. Vaikka teoria ei täysin pysty todistamaan tätä väitettä ja tulokset empiirisistä estimoinneistakin ovat moninaiset, tutkimukset metsäteollisuustuotteiden kaupasta ovat usein viitanneet valuuttakurssimuutosten vaikuttaneen vaihdettuihin määriin.

Aiemmat tutkimukset koskien Suomen metsäteollisuustuotteiden vientiä ovat raportoineet valuuttakurssimuutosten käyttöä vientihinnan muuntamiseen ostajamaan valuutassa, erityisesti valuutan arvon tarkoituksellisen muuntamisen seurauksena. Esimerkiksi devalvaatioita, joita usein käytettiin kotimaisen hintatason noustessa liian korkeaksi, hyödynnettiin metsäteollisuudessa nostamalla hintakilpailukykyä ja vientimääriä. Euroopan talous- ja rahaliiton (EMU) kolmannen vaiheen realisoituminen myötä vuoden 1999 alusta sitoi jäsenmaiden valuutat yhteiseen valuuttaan, euroon, peruuttamattomalla kiinteällä kurssilla, mikä samalla poisti mahdollisuuden itsenäiseen kurssin arvon muuntelemiseen. Lisäksi valuuttakurssivaikutukset ja sitä myöten myös valuuttakurssiriskit ovat poistuneet kokonaan EMU:n sisäisestä kaupasta. Tämä on avannut kokonaan uuden markkinan monelle pienelle avoimelle taloudelle. Muutos liiketoimintaympäristössä on samalla kuitenkin myös merkinnyt mahdollisia sopeutumisongelmia suomalaisille metsäteollisuusyrityksille.

Tämän tutkimuksen tarkoituksena on tarkastella EMU:un liittymisen vaikutuksia Suomen sahatavaran vientiin sen päämarkkinoille Iso-Britannian ja Saksaan. Johtuen Suomen tärkeimmän kilpailijamaan, Ruotsin, jättäytymisestä rahaliiton ulkopuolelle, päätettiin sen sahateollisuuden viennin kehitystä käyttää referenssinä itsenäisen rahapolitiikan menettämisen seurausten arvioimiseen. Viime vuosina koettu Ruotsin kruunun heikkeneminen suhteessa euroon on tuonut erityistä lisämielenkiintoa aiheeseen. Painopiste on suhteellisten hintojen tutkimisessa ja niiden vaikutuksissa vaihdettuihin määriin. Tätä tutkitaan pitkän ajan valuuttakurssin läpimenon (pass-through) seurauksena vientihintoihin tarkasteluajanjaksolla 1995-2008. Tutkimuksen empiirinen estimointi toteutetaan käyttämällä Johansenin yhteisintegroituvuusmenetelmää kullekin yksittäiselle, kahdenvälistä kauppaa kuvaavalle, osittaisen tasapainon mallille.

Tulokset antavat viitteitä huomattavista valuuttakurssivaikutuksista Suomen sahateollisuuden vientiin. Yleisesti, euron heikkeneminen on voimistanut viennin kysyntää, kun taas valuutan vahvistuminen on vaimentanut sahatavaran tuontimääriä Suomesta. Ruotsalaiset sahatavaran viejät ovat puolestaan omaksuneet suurelta osin vastakkaisen hinnoittelustrategian. Tämä on tarkoittanut sekä vakiintuneempaa hintaa sahatavaran tuojille Ruotsista että kysyntää ruotsalaisille viejille. Nämä tulokset edelleen viittaavat siihen, että Ruotsin kruunun heikkeneminen ei ole vaikuttanut koko painollaan suomalaisten viejien hintakilpailukykyyn. Kuitenkin, ruotsalaiset sahatavaran viejät ovat pystyneet saavuttamaan korkeampia voittoja, mikä on osaltaan ollut vaikuttamassa viimeaikaisiin tuotannon siirtoihin Suomesta Ruotsiin.

Avainsanat — Nyckelord — Keywords

EMU, Johansenin yhteisintegroituvuus, sahatavara, valuuttajousto, valuuttakurssi, vientikysyntä,

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Helsinki, December 2009

Jyri Hietala

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1. INTRODUCTION

1.1 Background and justification of the study

Forest industry is globally seen as domestic manufacturing, where most of the production is directed to local consumption. Yet, for example the Finnish forest industry exports most of its products abroad. Under these circumstances producers are highly dependent on the demand in international markets, which consequently will also decide the overall profitability of the firms. Maintaining a competitive position, besides to fellow domestic competitors, also against foreign firms becomes then an additional consideration for all producers competing in international scale. The exchange rate in particular, i.e. the value of the domestic currency relative to that of the trading partners, has been commonly perceived as the most important macroeconomic variable in international trade as it essentially determines the short-term profitability and competitiveness and thus each firms survival in the short run (Kim et al. 2003). For example, a country experiencing depreciation in the value of its currency, production costs compared to other regions of the world decline immediately, making its goods more competitive in the global market. However, in the longer run prices begin to inflate, restraining gradually the advantage. (Daigneault et al. 2008) In the long run, firms have also the possibility to act strategically regarding exchange rate induced price changes e.g. by hedging against unfavourable currency developments. Firms may also anticipate future currency developments and stipulate them in their long-term sales contracts. The main point still stands, that the inference of changes in the exchange rate plays an important role in international trade.

The increasing interest on exchange rates rose from the breakdown of the Bretton Woods system in 1973. Explanations were demanded for the question whether floating exchange rates would truly play an equilibrating role in trade balances as it was felt that currencies had actually moved way off from their equilibrium during the era. (Goldberg and Knetter 1997) In this context, a large literature has developed, where a number of authors have been motivated to step back and study the underlying relationship between exchange rates and internationally traded goods' prices. Nowadays this relationship is commonly known as exchange rate pass-through, which refers to the degree to which exchange rate changes are reflected in the destination currency prices of traded goods.

The main inference of the exchange rate pass-through phenomenon relates to its impact on price competitiveness. It has been largely debated whether firms pass through some or all of the currency change into export prices denominated in the importers currency. For example in case of currency depreciation, do firms decrease the export price to gain market share or do they absorb the exchange rate change in higher profit margins and keep traded quantities more stable? For a small open economy like Finland, the assumption is that firms are price takers so that under perfect competition only profit margins will be affected. Previous studies concerning Finnish forest industry exports have, however, reported the use of exchange rate changes to gain price advantages against competitors, especially as a consequence of deliberate currency realignments (devaluations). This would entail imperfect competition in the market and some level of market power exploited by the exporting firms.

The realization of the third phase of the European Economic and Monetary Union (EMU) on the beginning of 1999 has now eliminated the possibility to realign the currency value from all of its participants. This could have caused severe adaptation problems to some Finnish forest industry firms, as exchange rates have in the past had important effects on exports. Moreover, price comparisons have become easier in the EMU region, which could have further increased the competition between producers from different origins (Hänninen 1998a). These considerations were to some extent turned a blind eye to in debating over the pros and cons of joining the EMU. Instead, many business executives and finance specialists saw mostly positive effects e.g. from the removal of the exchange rate buffer in intra-EMU trade, which was seen as a major benefit to producers due to lowered transaction costs caused by the elimination of exchange rate risks. Yet, exports of Finnish forest products to the EMU region have actually been decreasing after foundation of the monetary union. (Hulkko 2008, p. 366)

Naturally, in non-euro trade the exchange rate still matters and this gives an opportunity for Finnish firms to price strategically regarding fluctuations in the value of the currency. For Finland's main competitor, Sweden, the choice of realigning the krone has remained as an option and, *ceteris paribus*, Swedish firms have the possibility to price discriminate in all markets. How this has affected the competitive position of Finnish forest industry firms in their main export markets will be under consideration in the present study.

1.2 Previous studies

The relationship between exchange rates and relative prices has been under interest for the past few decades. The spectrum of the results is widely mixed and there are no generally accepted reference rates; rather the exchange rate pass-through is found to vary over countries, different industries and products, and even for the same product for varying time periods. Majority of the previous studies have found that the transmission of exchange rate changes into export prices is incomplete, so that part of the change is shifted into destination currency prices. Moreover, most of the studies have concerned the larger, less open economies, such as USA, Japan and Germany, and also to a lesser extent concerning forest products trade. In general, the relatively few studies undergone hold the same opinion that exchange rate changes play a key role in international trade of forest products. However, both theoretical and empirical contributions to the literature fail to conclusively validate this hypothesis.

First of all, exchange rate effects have been studied for large economies such as USA. Uusivuori and Buongiorno (1991) estimated the degree of exchange rate pass-through for US exports of 11 disaggregated forest industry products (pulp, paper and sawnwood) in six European countries and Japan. A monthly bivariate time-series model of export price and exchange rate was used for the period 1978-1988. The results indicated incomplete pass-through and, in addition, that appreciations of the dollar tended to increase foreign prices more than devaluations decreased them i.e. the degree of pass-through was asymmetric. This would suggest that dollar devaluations might not be effective in increasing exports of forest products. Signs of exchang rate asymmetry have also been found in studies conducted by Daigneault et al. (2008) and Bolkesjø and Buongiorno (2006). The results of formerly mentioned study indicated larger effects of US dollar appreciations than equivalent dollar depreciations on U.S. production amounts of forest products, which would eventually affect exported amounts differently as well. In the latterly mentioned study, using monthly panel data for the period of 1989-2004 the short- and long-run exchange rate pass-throughs were estimated for several forest product categories distinguished by country of origin, most of them to the main markets in Europe. The results were widely variable between the different products, but the general conclusion was that exchange rates do affect competitiveness in the global markets even in the short run. This finding is conflicting to the results of the prior mentioned study, which suggested minor short-run effects.

Bilateral trade between USA and Canada has been of much interest for several researchers as well. Jennings et al. (1991) do not find strong evidence for exchange rate effects in Canadian sawnwood exports to the U.S. in estimating a 10-variable vector autoregressive model for the period 1968-1987. On the other hand, Sarker (1993, 1996) finds one long run cointegrating relationship among five excess demand factors of sawnwood, one of them being the bilateral exchange rate of the Canadian and U.S. dollar. In U.S. newsprint imports from Canada a multivariate cointegration model was constructed by Jee and Yu (2001) for a monthly period of 1988 and 1996, and the results indicated a high long-run exchange rate elasticity, which would again imply large effects on traded quantities. Baek (2007) examined the U.S.-Canada trade of five forest products for quarterly data between 1989 and 2005 and the results substantiate the finding that in the short-run exchange rate does not play a significant role in determining U.S. trade. In the long-run, the exchange rate was however found to play a pivotal role in determining the U.S. trade balance with Canada. In contrast, studies by Nagubadi et al. (2009) find no evidence for long-run exchange rate effects on sawnwood exports by estimating a demand equation with Johansen's cointegration method for annual data covering the period 1958-2005. The finding of Alavalapati et al. (1997) in a cointegration study of exchange rate pass-through to woodpulp prices in the U.S. implied also only minor market power exploited by Canadien exporters and hence lower exchange rate effects on relative prices.

Exchange rate effects on relative prices and traded quantities have been under research for smaller economies as well. Vesala (1992) studied exchange rate pass-through into prices of aggregate paper, paperboard and pulp products exported from

Finland to Western Europe and the U.S.. Applying Ordinary Least Squares (OLS) method, a markup pricing equation was estimated for quarterly data between 1975 and 1991. The results give clear evidence of incomplete pass-through and furthermore somewhat lower rates in the U.S. market. This would entail lower market power of Finnish exporters in USA than in Europe. Exchange rate effects on Finnish export prices of pulp and paper products have been studied by Hänninen and Toppinen (1999) and Hänninen et al. (2000) as well. The pass-through elasticities of newsprint and pulp exports in British and German markets were estimated from a markup price equation applying Johansen's cointegration method and using quarterly data from 1980 to 1994 in the formerly mentioned study and monthly data during the period 1986-1997 in the latter study. According to the exchange rate elasticities, pass-through to foreign currency export prices has been incomplete, so that Finnish exporters have been, to some degree, able to use devaluations to boost their exports in these markets. In general, the pass-through estimates by Hänninen et al. (2000) were slightly lower, implying possibly tightening competition in the markets.

A similar study to the aforementioned was conducted by Hänninen (1998a) for sawnwood exports to the UK market. However, instead of using a single price equation, a system structure was constructed by including a demand equation in the final model. The study applied the Johansen's cointegration method and the data were quarterly, covering the period 1978-1994. Contrary to the studies of Finnish pulp and paper exports, the exchange rate pass-through was found to be almost complete in sawnwood exports. This would indicate that Finnish sawmills have not been keen to change their markups (profitability); rather devalutions of the Finnish mark have been used to increase price competitiveness by the full amount and hence increase exported quantities (market share). Also Menon (1993a), in studying exchange rate pass-throughs for disaggregated manufactured imports, estimated larger pass-throughs for wood products than for paper products.

Related papers have also addressed the question of integration in the main export markets by studying the relative prices of several forest industry products. However, as price differences between competitors may be due to other factors (e.g. product quality, transportation costs etc.) than purely differences in pricing strategies regarding exchange rate changes, this subject will be overlooked in the empirical part of the study.

1.3 Aim and outline of the study

This study examines the effects Finland's joining in the European Monetary Union has had on its forest industry's competitiveness in foreign trade. As Finnish sawnwood exporters have been seen to be using exchange rate induced price changes rather thoroughly in the past, the sawnood industry will be under consideration in the present study. The export markets will comprise the main markets for Finnish sawnwood industry, the United Kingdom and Germany. This will give the possibility to attain insight from exports to an EMU and non-EMU destination. The non-attendance of Finland's most important competitor, Sweden, in the EMU will serve as a reference point for the possible effects the loss of an independent monetary policy has had. Additional interest brings the fact that the Swedish krone has been weakening against the euro for the past years.

In brief the main research problem was:

> ***"How has joining the EMU affected Finnish sawnwood industry's competitiveness in its main export markets?"***

The emphasis is on studying relative prices and its effects on traded quantities through the long-run exchange rate pass-through phenomenon. This will be done by applying an econometric method for the separate partial equilibrium model systems for each bilateral trade of Finland and Sweden to both of the destination markets. The main research problem can then be further devided into three sub research questions:

- Are there identifiable differences in Finnish and Swedish sawnwood exporters' pricing strategies regarding exchange rate changes?
- Do the exporters price differently between an EMU and non-EMU destination market i.e price-to-market?
- Have Swedish exporters gained price competitiveness as a consequence of a weak krone against the euro or are the markets working competitively?

The outline of the study is as follows. Chapter 2 will give an overview of the import markets under consideration. The competitive structure in the UK and German sawnwood market will be examined through the development of the main competitors' market shares and the overall imports in the destination markets. Chapter 3 will present the theoretical framework of the study by reviewing the theory on exchange rate pass-through and its related literature on market integration. The data together with the equations used in estimation will be summarized in Chapter 4. The Johansen's multivariate cointegration method applied in the present study and the testable hypotheses will be considered in this section as well. Chapter 5 will then present the results obtained from the empirical estimation. This will be followed by a summary and discussion of the findings in Chapter 6. Finally, conclusions with suggestions for further research will be considered in Chapter 7.

2. OVERVIEW OF THE SAWNWOOD EXPORT MARKETS

Both Finnish and Swedish forest industries are highly export-oriented, which means that domestic demand is not sufficient to guarantee the production capacity in these countries. For example the Finnish sawmilling industry has exported around 55% to 65% of its total sawnwood production for the past years. The equivalent figure for the Swedish sawnwood producers has been between 60% and 70%. (Finnish Statistical… 2008; Swedish Forest Industry… 2008) An important implication following from the high dependency of domestic sawmills on international markets is that changes in the world economy can then affect greatly annual production levels and, further, the exporting firms' overall profitability. This is especially true in the sawnwood industry, which is seen as very sensitive to economic fluctuations. This is mainly because most of the produced sawnwood is used in construction, which is one of the first sectors to dampen due to economic depressions. (Tilli et al. 2001) Indeed, past recessions in the world economy have hit severely many sawnwood producers, and mill closures and standstills have been rather common for the industry in these circumstances. The following section will next look closer to the Finnish and Swedish sawnwood industries' main exporting markets, UK and Germany, and examine how the market shares of the main suppliers have developed throughout the period under observation.

2.1 The UK sawnwood market

The main sawnwood exporters to the UK market have traditionally come from the forest-rich Nordic countries, namely Finland, Sweden, and Russia, and more recently the Baltic region. In 2008 these accounted for almost 80 per cent of total UK sawnwood imports. Although the UK has been increasing its own sawnwood production for the past decades, it is still highly dependent on imports. From 1995 the annual domestic production volumes have gradually increased and exceeded 3 million cubic metres the first time in 2007. Yet, in 2008 the overall recession in forest products trade, specifically due to collapses in housing, dampened the production back to the previous years' levels. At the same time sawnwood imports have risen from 6 million cubic metres to almost 9 million cubic metres, only to fall in 2008 to the lowest level experienced since year 2000 (Figure 2.1). Especially from 2002 onwards, the increasing demand for sawnood can be seen as an increase in average unit prices payed by the UK importers. Consequently, the beginning of the recession in 2008 meant a steep decline in sawnwood prices. As the UK's own export volumes have traditionally been fairly low, the apparent sawnwood consumption (apparent consumption = domestic production + imports – exports) has been continuously increasing until the end of 2007. (FAOstat; Eurostat) As a result, the accounted share of imports has remained at a constant high level of approximately 75 per cent. Current projections however indicate that sawnwood self-sufficiency is expected to peak at 50% by 2025 (Royal Forestry Society). Nevertheless, imported sawnwood will presumably continue to play a major role, as it is seen in many ways superior to the UK's domestic sawnwood.

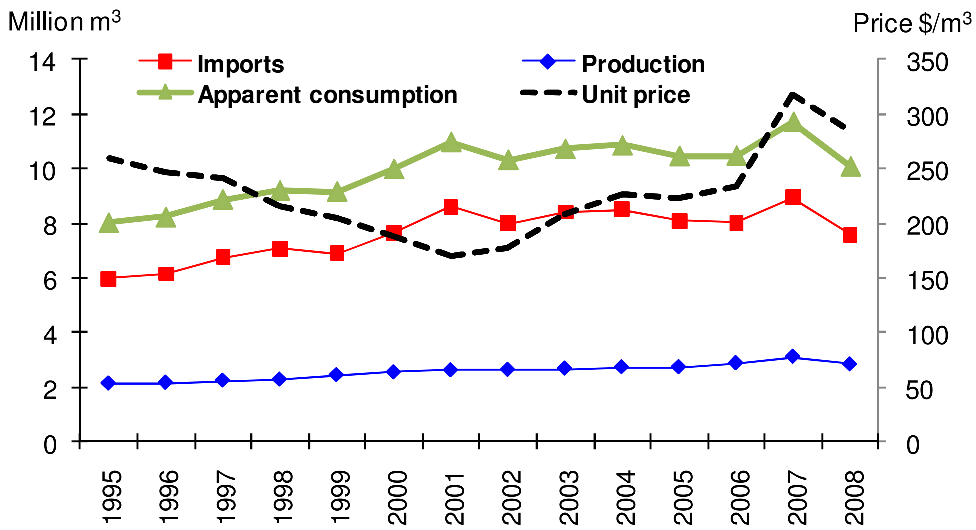

Figure 2.1 The UK's sawnwood imports, production, apparent consumption and average import unit price, 1995-2008. Sources: FAOstat; Eurostat

Import shares of the main suppliers in the UK sawnwood market show relatively large and, to some extent, opposite business fluctuations (Figure 2.2). Finland's share seems to have developed somewhat in parallel with the UK's total sawnwood imports. Indeed, from the beginning of the observation period until 2001, together with a gradual increase in total imports of the UK, Finnish sawnwood exporters were able to increase substantially their relative import amounts: From an initial 13% market share to over 20%. Thereon, the more stable development in the UK's total imports has affected imports to decline. In 2008 the Finnish market share hit the lowest it has been for the whole period, being only the third largest importer in the UK market with an 11% share of total imports. As will be shown in the following chapters, this development could be an outcome of exchange rate fluctuations. On the other hand, a more favourable price development in some other markets could have given incentives to change the demographic structure of exports. This way, the decrease of exports in one market can be seen as a conscious decision by exporters. Finnish sawnwood producers have been heavily positioning themselves in the Japanese market from 1998 onwards, so that in 2008 it was already the second largest importer of Finnish sawnwood. The same kind of development has been undergone by Swedish exporters as well. (Eurostat)

In contrast to Finnish sawnwood exporters, Swedish exporters have experienced the opposite development, where a rapid decrease in market share turned into an increase from 2001 onwards. This is rather surprising, as exchange rate developments against the pound sterling have been parallel for Finnish and Swedish exporters and therefore would indicate not being an outcome of relative price advantages. Overall, Swedish exporters have been able to maintain their market share better than most competing exporters, and has remained as the main sawnwood supplier to the UK market with a 35% share of total imports in 2008. (FAOstat; Eurostat)

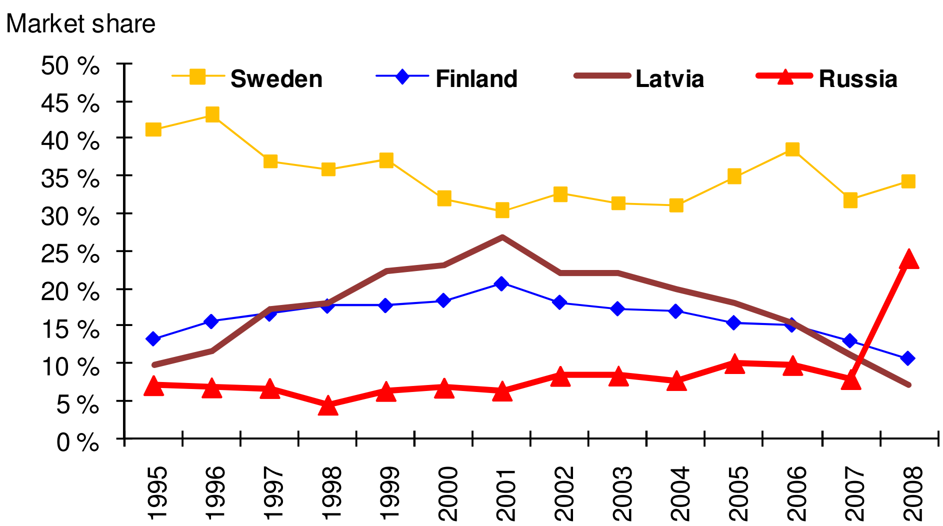

Figure 2.2 Market shares of main supplier countries in the UK sawnwood market, 1995-2008. Sources: FAOstat; Eurostat

Competition in the global forest product markets has been tightening for the past two decades or so, as many low-production countries have entered the markets. This is particularly true in the Eastern Europe, where the collapse of the socialist regime in the beginning of 1990s and, furthermore, the opening if the borders for free trade, have induced activity in nearly all sectors of the economy. Especially for markets of bulk products, such as sawnwood, many new competitors have risen to compete in international scale. (Mutanen 2006) For example from the Baltic region, Latvia has become a serious competitor to the more traditional forest industry countries and in 2001 it was, in fact, competing against the Swedish exporters for the main sawnwood importer in the UK market with a 27% market share. Since then, the position has been rapidly lost and nowadays the relative share of exports has dropped even under the 1995 level of 10%. After the collapse of the Soviet Union, the Russian Federation experienced a large recession, where the sawnwood production and exports plunged dramatically. Little by little, the country with largest forest resources in the world, has been able to climb its way back up, and can be nowadays considered as a major competitor in the international sawnwood markets again. This development was, at least partly, initiated by the devaluation of the rouble in 1998 (Mutanen 2006). Just as to justify the continuity of the ascending trend, Russian sawnwood exports almost tripled from the previous year's level in 2008, and became the second largest sawnwood exporter to the UK with a 25% market share. This was however not an outcome of overall increasing exports; rather the total sawnwood exports decreased in 2008, but Russian exporters shifted exports from other markets, such as Germany, to the UK market. (FAOstat; Eurostat)

2.2 The German sawnwood market

The most important sawnwood suppliers in the German market are mostly the same countries as in the UK market. One major difference between the separate markets however relates to their self-sufficiency. Whereas the UK has always been largely dependent on sawnwood imports and their own exports have been of low volumes, in the German market the trend has been on increasing own production and exports, and in contrast, decreasing imports. In fact, Germany has been one of the main sawnwood exporters in the world for a long time and the development seems to be continuing. In this sense, the UK can be seen as a more traditional importer compared to Germany.

In spite of large domestic production of sawnwood, Germany has been classified a net importer for a long time. Yet, from 2003 onwards the situation has changed: Germany became a net exporter of sawnwood the first time then and this trend has been ongoing on an increasing fashion thereafter. In figure (2.3) this development can be seen as the difference between the lines representing production and apparent sawnwood consumption. In 1995 the sawnwood production of 13 million cubic meters still fell short of the apparent consumption level approximately 3,5 million cubic meters, which is equivalent to the amount imports (5 million m^3) exceeded exports (1,5 million m^3). In 2003 the production totaled slightly over the apparent consumption and in 2008, with imports just barely over 3 million cubic meters and exports over 7,5 million cubic meters, the difference had risen by then to over 4,5 million cubic meters. Consequently, the accounted share of imports in apparent sawnwood consumption has decreased from 30% to fewer than 20% in a decade. The decline in sawnwood demand has had an effect on the average unit price payed by German importers as well. Although the unit price has been rising as in the UK market, overall the increments have been smaller, resulting in relatively much lower prices compared to the UK market. As in the UK market, although to a lesser extent, imported sawnwood will in the future still continue to play a role in the German market. (FAOstat; Eurostat) Tilli et al. (2001) point out that especially sawnwood originating from northern countries is often considered technically and aesthetically superior to the sawnwood of German origin, so that it is used in places having special requirements for the properties of wood material. This would indicate that imported sawnwood could not be fully replaced by Germany's own production as the demands for domestic and imported sawnwood are separate.

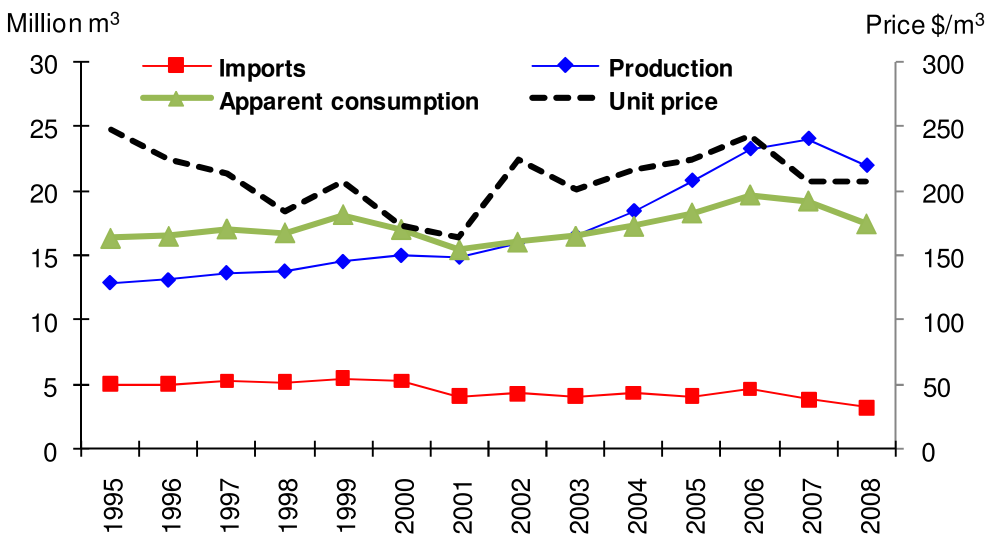

Figure 2.3 Germany's sawnwood imports, production, apparent consumption and average import unit price, 1995-2008. Sources: FAOstat; Eurostat

Whereas in the UK market import shares have shown relatively large negative correlations among the main suppliers, especially between Finnish and Swedish shares, in the German market there appears to be much more convergence in the business cycles (Figure 2.4). Moreover, the German market seems more competitive than the UK market, as the relative shares of the main competitors have moved closer to each other so that no obvious market leader can be distinguished. This has presumably had an effect on the lower average unit prices payed by German importers compared to the UK importers.

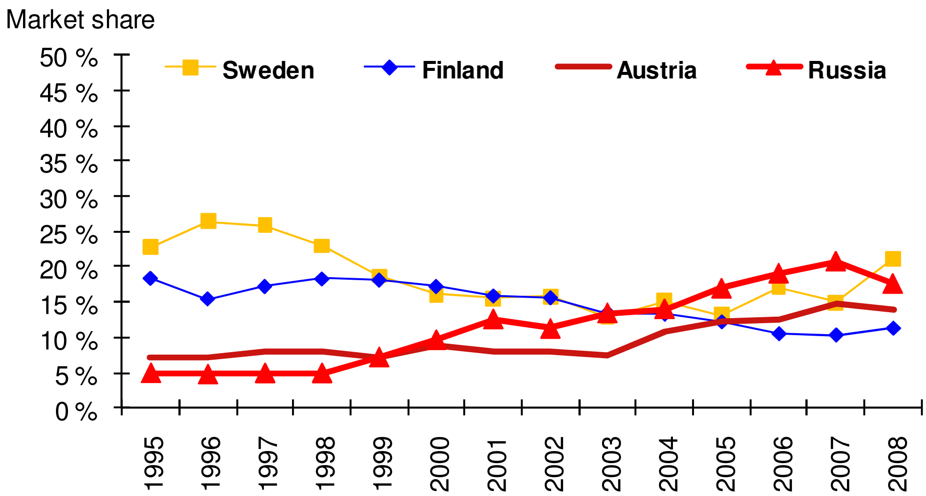

Figure 2.4 Market shares of main supplier countries in the German sawnwood market, 1995-2008. Sources: FAOstat; Eurostat

Again total imports seem to explain much of how Finnish sawnwood exports have developed. From the beginning of the observation period until 1999/2000, together with stable total sawnwood imports of Germany, the relative imports originating from Finland remained fairly stationary between 15% and 20%. At this time, Finnish sawnwood exporters were also competing for the largest market share in the German market. Since then the situation has changed quite remarkably. The overall decline in demand for exported sawnwood in the German market seems to have hit especially the Finnish producers, which have been continuously losing edge to other suppliers. As a consequence, in 2008 the Finnish exporters were just the fourth largest exporter into the German market, accounting for only 11% of all sawnwood imports. An interesting fact is that the beginning of the decline in exports took place around the same time as the euro was introduced. In the light of this, joining the European Monetary Union (EMU) seems not to have given Finnish exporters any kind of advantage against non-participants (e.g. Sweden) in intra-EMU trade.

In contrast to the UK market, where Sweden has been able maintain a distinctive dominant position, in the German market it has been of much harder work. It seems that the strengthening of the Eastern European low-cost sawnwood producers in the German market have shaken the position of the Swedish producers in particular, as the market share dropped dramatically at the same time as countries such as Belarus, Czech Republic, Poland and the Baltic States entered the markets. The incraesing role of these countries in the German market has supposedly had an effect on the more conservative development in unit prices as well. Also the devaluation of the rouble in 1998 has seemingly had an effect on the competitiveness of the Swedish exporters, although Mutanen (2006) has stressed that Russian sawnwood has not substituted Finnish or Swedish sawnwood in the German market. Still, as an outcome Sweden lost their dominant position in the German sawnwood market and the accounted import share dropped over 10 percentage points from 1997 (26%) to 2005 (13%). From there on, Swedish exporters have though been able to re-establish their position, so that in 2008 it was again the largest exporter in the market with a 21% share of Germany's total sawnwood imports.

In addition to the aforementioned supplier countries, Austria has also been a noteworthy actor in the German sawnwood market. In 1990s the amount exported to Germany however fell quite dramatically from the previous decade's level, and the market share remained below 10% for the whole period. In 1980s the analogous share was at 14%. According to Tilli et al. (2001) this was not due to a dampening in sawnwood production and exports in general, rather the Austrian producers have deliberately increased exports to other destinations, such as Japan and Italy, which were presumably seen as more attractive markets by the Austrian sawmills. In the 21st century the situation has returned to what it was before the preceding decade and Austria has gradually increased its share of imports in the German market back to the 1980s average level. The development of Russian sawnwood exports in the German market has been similar to that of in the UK market. The devaluation of the rouble in 1998 set Russian exporters on an advantageous position price competitiveness-wise, which in effect enabled them to substantially increase exports to Germany. Indeed, from an initial market share of 5% in 1998 the relative imports rose to account over 20% in 2007 and Russia overtook the market leading position. In 2008, as a consequence of overall decreases in Russia's sawnwood exports and moreover in shifts to more attractive destination markets, the relative imports from Russia decreased slightly in the German market and the positions were reversed back with Sweden.

3. THEORETICAL FRAMEWORK

3.1 International trade and nature of market competition

The classical trade theory explains international commodity trade by the concept of comparative advantage. The main underlying premises are perfect competition, constant-returns-to-scale and homogenous products. In a perfectly competitive market there are many buyers and sellers, none of whom represent a large part of the market. Firms are price takers; they maximize profits by adjusting output at the current price and cannot influence the price they receive for the product. (Krugman and Obstfeld 1997, p. 124) The Heckscher-Ohlin (H-O) model of classical international trade theory teaches us that different nations should gain comparative advantage in products that use intensively those resources that the nations have an abundance of. Comparative advantage of a country for a product should then show up in the relative importance of exports of this product in the total trade of the country when compared to countries not exhibiting a similar advantage. When projected into the forest sector, the model predicts that of two countries with similar domestic demand for forest products, the country with relatively richer forest assets will also have larger net exports of forest products. In general the H-O trade model has performed poorly in empirical tests on international trade, but for forest products trade the model has been able to explain well cross-country or cross-regional variation in net exports of forest products. (Uusivuori and Tervo 2002) Moreover, recent empirical work has met with striking success in combining factor endowment differences with technology differences as an explanation of observed trade patterns (Davis and Weinstein, 2001).

The characteristics of perfect competition are often found to be only theoretically applicable and pure examples from real world are hard to find. As the classical trade theory explains international trade only by differences between countries, also their exports should consist of only those goods whose factor content reflects their underlying resources. Yet, actual trade patterns seem to include substantial two-way trade in goods of similar factor intensity, a fact seemingly at odds with the prediction of H-O theory. (Markusen and Venables 2000) It is well known that many industries are characterized by economies of scale, affecting competition to be less than perfect as well. Hence, the assumptions of classical trade theory are less than sufficient to guarantee the early trade models and have mainly been used only in general equilibrium models. For example large forest sector models are often based on the assumption of prefect competition: ETTS V presents forecasts of forest products trade in this framework (Brooks et al. 1995) as well as the European Forest Sector Outlook Study (EFSOS) by Kangas and Baudin (2003). The same assumption is also used in some partial equilibrium models for the global forest sector, e.g. the global forest sector model (EFI-GTM) conducted by Kallio et al. (2004), a model for analyzing and projecting global forest products production, consumption and trade (Buongiorno et al. 2000) and the Forest Cluster Model (FCM) to assess the changing market conditions for the Swedish sawmilling industry (Lundmark 2007) are based on perfect competition. Indeed, there are some attributes in forest industry, which would imply perfect competition; in pulp and paper industry, fairly universal product standards and specifications and commonness of mergers and acquisitions as well as direct foreign investments in capacity and, in sawnwood industry, relatively homogenous products. (Hänninen 1998b, p. 21-22) Still other frameworks have been developed to better explain real world intra-industry trade.

The basis of new trade theories have been imperfect competition and increasing-returns-to-scale. In imperfectly competitive markets the amount of sellers (or buyers) are limited and products are often differentiated. Firms are no longer price takers; the price of its product can either be assumed to be set by the firm, so that demand is determined by the price of the product; alternatively, the firm may be assumed to select its level of operation and let the price be determined in the market. The optimal price will be the same in either case as each individual firm faces a downward sloping demand curve. (Honkatukia 1995) The assumption of increasing returns provides a simple explanation of intra-industry trade, because even if differences in factor rewards or technology do not create an incentive for specialization and trade, the advantages of large-scale production will still lead countries to specialize and trade with one another. (Helpman and Krugman 1985, p. 3) The study of trade in the presence of increasing returns is still ongoing and there is yet no generally accepted theory of imperfect competition, especially regarding oligopolistic behavior (Krugman and Obstfeld 2006, p. 121).

Often smaller, partial equilibrium models, assume imperfect competition between competing producer countries. Indeed, a number of studies on individual forest products trade, often applying the theory of Armington (1969), have been based on imperfect competition. For example Hetemäki et al. (2004) have used this approach in explaining and forecasting Finnish sawnwood demand in Germany. Studies concerning exchange rate effects on Finnish pulp, paper and sawnwood products' prices in the UK and Germany (e.g. Hänninen et al. 2000; Hänninen 1998a; Hänninen and Toppinen 1999) have commonly applied the model of Armington as well.

The assumption of imperfect competition is often well justified as there are numerous features in forest industry that suggest the competition being less than perfect. The concentration of production to a few producers hinders perfect competition and this is fairly common in forest industry. This is the situation for example in the Finnish sawnwood sector, where the three largest producers (Stora Enso, UPM-Kymmene and M-real) have traditionally accounted for most of the production (Hänninen 1999a). Firms also avoid competing with price by deliberately cutting production to maintain certain price levels (Ronnila 1995). This is especially true in a recession, when standstills and shut-downs are used to downsize the supply. Entering and exiting the market is often also not in accordance with perfect competition, as investment costs of new plants are high and getting rid of excess capacity is complicated. In sawnwood industry, regionally concentrated trade and differences in building codes, product dimensions and grades between countries are signs of imperfect competition. (Hänninen 1998b, p 22) Buongiorno et al. (1979) have emphasized that for example preferences for lumber quality, business practices as well as attachments to a particular producer may create distortions even in cases where products are relatively homogenous. These are related to switching costs that may occur when switching for example from one supplier to another (Froot and Klemperer 1989). Supplying firms can also create tight bonds with certain customers for example by using discounts for repeat-purchases or differentiating their product service from that of others.

3.2 Modelling international trade

3.2.1 Problem of the importing firm: Export demand function

The export demand theory of Armington (1969) has been widely used in modelling international trade. The model assumes that competing products from different countries of origin are imperfect substitutes for each other. Further, import demands are assumed homothetic and weakly separable so that the consumers' decision process occurs in two stages. In the first stage, the total quantity of imports of a product is determined at the macro level. In the long run, sawnwood demand can be seen to depend on population growth and the proportion of sawnwood used for construction purposes in general. In the short run, the economic situation affects new building and thus sawnwood demand. In the second stage, the quantity to be imported is allocated among competing suppliers using constant elasticity of substitution (CES) demand functions. By this mean it is possible to identify consumers' decision between sawnwood and other competing products and sawnwood demand from different origins of production. The weak separability condition saves degrees of freedom in the estimation and makes it possible to reduce the number of variables in the analysis. This makes it possible to simplify the estimation procedure and is an essential advantage in models of international trade that consist of many products and several exporting and importing countries. (Hänninen 1998b p. 23) When the above assumptions hold, the demand equation for a country's product can be expressed as follows (Armington 1969)

$$X_{ij} = \beta_{ij}^{\eta} X_j (P_{ij} / P_j)^{-\eta}, \qquad (3.1)$$

where X_{ij} and P_{ij} are the importing country's demand and price of product j from country i, X_j and P_j are the total demand and average price of product j in the importing country, η represents the constant price elasticity and β_{ij} is a constant.

In the present study the general model is modified to better represent the decision process of sawnwood importing firms. The theoretical model for describing the demand for sawnwood imports follows the two-stage approach presented first by Fuss (1977). In sawnwood trade the same procedure has been applied for example by Mutanen (2006) in studying German sawnwood imports, by Hänninen (1998a) in examining Finnish sawnwood demand and exchange rate pass-through in the UK market and Nagubadi et al. (2004) in studying the substitutability of softwood lumber imports from Canada with the USA's own lumber production. Because sawnwood is an intermediate product, the model can be derived from a cost function of the end using industry rather than from consumer's utility, as in the Armington's model. Hence, the two-stage demand procedure assumes cost-minimizing behavior of a sawnwood end user in the importing country. First the representative end-user decides the optimal amount of aggregate sawnwood and other inputs (*S*=sawnwood and *O*=other) required to produce a certain output, *Y*. Following Mutanen (2006) this can be described by the total cost function, $C^T = f(P_S, P_O; Y)$, where C^T is the total cost as a function of the input expenditures for a certain output. The total expenditure on sawnwood is, further, a function of sawnwood prices originating from the competing countries (including domestic production), such that $P_S = P_S(P_{S1}, P_{S2},\ldots, P_{Sn})$. In accordance with the Shephard's lemma, the derivation of cost function with respect to input prices yields the optimal, cost minimizing, input demands. At the second stage, a choice is made between sawnwood from the different origins by optimizing the sub-cost functions, which in this case can be presented as $C^S = f(P_{S1}, P_{S2},\ldots, P_{Sn}; S)$. C^S represents the total cost of sawnwood input, P_{Si}'s are the prices of sawnwood originating from different countries (i = 1,…, *n*) and *S* is the total amount of sawnwood derived from the first stage optimization.

From the above cost-minimizing behavior of the end user, the demand relation can be derived for a single exporting country. Yet, in order to analyze exchange rate effects, we separate the exchange rate variable. Now the sawnwood export demand model, as used in the present study, can be formulated as follows (Hänninen 1998a):

$$X_i = \beta_i^{\eta} X_o (P_i / P_o ER_i)^{-\eta}, \tag{3.2}$$

where X_i and P_i are the sawnwood quantity demanded e.g. from Finland and the Finnish export price in home currency in export country *i*, X_o and P_o are the total sawnwood demand and weighted average foreign currency price of competitors, ER_i is the nominal exchange rate of country *i* (domestic currency per unit foreign currency), η is the constant price elasticity and β_i is a constant.

Assumptions of the modified model are the same as in the Armington's model: quantities of sawnwood imported from different origins are imperfect substitutes to each other and constant elasticity of substitution is assumed between sawnwood from different origins. Also the weak homothetic separability of the production function is required for the two-stage optimization procedure. This implies that market shares are affected only by price relations and not by the size of the market itself. (Hänninen 1993)

For estimation purposes, the above equation is transformed into logarithmic values. The estimated export demand relation then becomes

$$x_i = -\eta\,(p_i - p_o - er_i) + x_o + a_0 + \varepsilon, \qquad (3.3)$$

where lower case letters denote logarithmic values of the corresponding upper case letters in equation (3.2), a_0 is a constant term and ε is an error term. The symbol η is the price elasticity of demand and equation (3.3) is homogenous of degree one in the nominal variables (p_i, p_o and er_i). (Hänninen 1998a)

3.2.2 Problem of the exporting firm: Export price function

The export demand equation derived above stated that the final demand decision is based on the relative prices of the competing products from different countries of origin. This in turn implies that the problem of exporting firms becomes setting the price accordingly so that profit will be maximized. In perfectly competitive markets prices in domestic currency terms must always be equal to marginal costs. In the present study it is however assumed that a representative exporting firm produces exclusively for an imperfectly competitive destination market and employs constant-returns-to-scale technology. The exporter maximizes profit by taking the competitors' price and supply of sawnwood as given and by setting the price in home currency, P_i, as a constant markup over the unit production costs, C_i. With, X_i, standing for export quantity, the exporter's profit, V_i, can be defined as

$$V_i = (P_i - C_i)\,X_i, \qquad (3.4)$$

and the first order conditions for profit maximization imply that the firm equates the marginal revenue from sales to the marginal cost of production. The profit maximizing price, in case of a constant markup, is thus obtained the following way

$$P_i = C_i \, \eta / (\eta - 1), \qquad (3.5)$$

where η is the price elasticity of demand. (Hänninen 1998a) The assumption of constant substitution elasticity (CES) implies that the firm chooses a markup equal to $\eta / (\eta - 1)$, which denotes the optimal gross markup. That markup will be common across firms and constant over time as firms would adjust the price optimally each period. (Freystätter 2003) Hung et al. (1993) show that by relaxing the constant markup condition, a more general case can be solved in which competitors' price determines the exporter's price. This can be demonstrated by the concept of a variable markup. The variable markup is obtained by assuming that the price elasticity of demand η is a function of price competitiveness, $(P_o ER_i)/P_i$, in the export market. Thus, assuming the markup to be variable and to respond to conditions in the destination market, i.e. assuming a non-constant elastic demand, implies that the exporter will adjust his markup in order to have a stable destination currency price when for example the exchange rate changes (Adolfoson 2001). The price elasticity of demand can be written as

$$\eta = \eta \, ((P_o \, ER_i) / P_i) \qquad (3.6)$$

The profit maximizing behavior, in case of a variable markup, can now be derived from equations (3.5) and (3.6), and shown to be

$$P_i = \phi \, C_i, \qquad (3.7)$$

where ϕ reflects the variable markup over unit costs and is dependent of the relative price. This can be approximated as:

$$\phi = \phi \, ((P_o \, ER_i) / P_i) = \phi' ((P_o \, ER_i) / P_i)^{\theta}, \qquad (3.8)$$

where $\theta\,(\geq 0)$ reflects the relative price elasticity of the markup. In case of a constant markup, $\theta = 0$ and $\phi' = \eta / (\eta - 1)$. A relation for the estimated price can be obtained now by substituting (3.8) into (3.7) and making a logarithmic transformation as in the demand equation (3.3):

$$p_i = \delta + (1 - \gamma)\,(er_i + p_o) + \gamma c_i + u, \qquad (3.9)$$

where $\gamma = 1/(1 + \theta)$, $0 < \gamma \leq 1$, $\delta = ln\phi'/(1 + \theta)$ is a constant and u is an error term capturing all factors, which affect the dependent variable, but are not included in the equation. As earlier, lower-case letters signify logarithms of the upper-case variables. The price of competing exports, p_o, and exchange rate, er_i, enter the relation with equal coefficients, and therefore in estimation the equality restriction is imposed on these coefficients. The export price equation is homogenous of degree one in nominal variables (p_o, er_i and c_i). (Kongsted 1998; Hänninen 1998a)

3.3 The theory of prices and exchange rates: From models to foundations

Price levels and exchange rate changes have an effect on the competitiveness of different nations. In the long run, national price levels play a key role in determining the relative prices at which countries' products are traded. A theory of how national price levels interact with exchange rates and affect relative prices is thus central to understanding the principles of international trade. (Krugman and Obstfeld 1997, p. 399) Product price and exchange rate movements also give information about the nature of competition. In perfectly competitive markets a product has a single world market price (representative price), and exchange rate movements have no effect on its foreign currency prices. In this situation exporters are unable to practice independent pricing strategies and e.g. input price increases cannot be adjusted with final product price increases without losing market share. Then again, price decreases are possible to maintain market shares in the short run, but not worthwile as competitors will follow in the long run. (Hänninen and Laaksonen-Graig 2000, p. 12) The following sections will present the fundamentals of the approach used in the study, i.e. the effects of price relations and exchange rate changes to product export demand and price determination.

3.3.1 The law of one price

One of the basic assumptions of the export demand theory of Armington (1969) is imperfect substitution between competing products from different countries of origin. This implies that, in the case of price differences, it is possible to measure the (elasticity of) substitution between supplier countries' products. The existence of price differences can be examined through the law of one price (LOP). It plays a critical role in international trade and in models of the trade of forest products in particular. (Buongiorno and Uusivuori 1992) The law of one price is a modification from the more common purchasing power parity (PPP) and states that in competitive markets free of transportation costs and barriers to trade, identical products sold in different countries must sell for the same price when expressed in same currency. The basic relationship between two prices under the law of one price can be presented formally as follows:

$$P_i = ER_i \, P_j, \qquad (3.10)$$

where P_i and P_j are the prices of a specific commodity in countries i and j, and ER_i is the currency exchange rate between countries i and j. (Krugman and Obstfeld 1997, p. 400) If the equation holds true, the markets for the commodity in question are assumed to be fully integrated and hence the markets can be characterized as perfectly competitive. This is referred to as the absolute LOP and is the result of commodity arbitrage: prices tend to converge to the same prices in all markets with time. The speed at which prices converge is a measure of market efficiency. If the (absolute) law, in turn, fails to hold true, the markets are assumed to be segmented, implying competition is less than perfect. However, Goldberg and Knetter (1997) remark this not always being the case. First, arbitrage is not costless; there are costs of gathering information, transporting goods, crossing borders and so on. Another concern is the validity of the assumption that goods are identical; for example goods produced in different countries are often not physically homogenous and prices of goods sold in different locations have different amounts of transportation, distribution and retail value-added underlying them. These can create price differences for products from different origins and thus imply imperfect competition by the absolute LOP, although the markets are in fact working competitively. The absolute LOP is assumed to be more applicable for homogenous product groups rather than differentiated products. The relative LOP is looser in its assumptions and allows for a price difference of identical commodities if it stays constant in time. In general the relative LOP assumption is viewed as more realistic and thus often used in empirical studies. (Hänninen and Laaksonen-Craig 2000, p. 17) Exchange rate changes can also have effects on prices from different countries of origin and hence may affect the existence of the law of one price. This is the topic of the next section.

3.3.2 Exchange rate pass-through in exports of a small open economy

3.3.2.1 Introduction

The debate over fixed versus flexible exchange rates has been a long-running saga in the international economics literature. The exchange rate, the value of the domestic currency relative to that of the trading partner's, is seen as one of the most important macroeconomic variables affecting trade flows of forest commodities. Indeed, forest industries competing in international markets have argued strongly for policies depreciating their home currencies, as this would presumably improve their competitiveness. (Bolkesjø and Buongiorno 2006) According to the J-curve effect, currency depreciation would improve the trade balance known as the volume effect. However, this is dependent on the initial value effect i.e. whether the currency change is realized in price competitiveness or by higher profits (or both), and is further dependent on the way in which the effects of the exchange rate movement are passed through or shared between exporter and importer. (Baek 2007)

Several specific macro and micro characteristics have been identified to influence the effects an exchange rate change will induce. Taylor (2001) and Campa and Goldeberg (2001) have for instance identified several factors affecting on the macro level: The size of a country, the openness of a country, exchange rate shock volatility and persistence, aggregate demand volatility, inflation environment and monetary policy environment. Brissimis and Kosma (2007) have on the other hand identified the importance of market power in the micro level and provide empirical evidence on this. Knetter (1993) and Yang (1997) have also identified industry-specific structures of competition being major determinants and further support the inference empirically. Especially, the degree of product substitutability and relative market shares of competitors are often recognized as important determinants in the industry level. The recent "new open economy macroeconomics" literature has, yet, emphasized the importance of nominal price rigidities and its implications to price determination through the choice of invoicing currency: A key channel being its impact on the effects of exchange rate changes to import prices (Bacchetta and van Wincoop 2005).

The relationship of exchange rate changes and internationally traded commodities' price changes is known in the trade literature as exchange rate pass-through (ERPT). More specifically, exchange rate pass-through can be defined as the percentage by which the destination-currency export price changes when the exchange rate changes by one percent. (Krugman and Obstfeld 1997, p. 469). As mentioned, in integrated markets producers are price takers and the law of one price is assumed to hold. This is the conventional theoretical presumption for small open economies for which the export demand is assumed to be perfectly elastic and/or the supply inelastic. Thus, exporters face an exogenously determined export price in foreign currency and there is immediate and complete pass-through of both exchange rates and world market prices to prices in their own currency. (Adolfson 2001) For example devaluations are not shifted into foreign currency export prices without counteractions from competitors, and hence the markup has to adjust, leading to fluctuations only in the firm's profits. Swift (2001) has recognized that the "dependent economy" assumption is more generally remained as the explanation when an exchange rate change is isolated in its effects to a single small economy and when the market share held by the individual country is relatively small.

If markets are, instead, segmented for example through differences in demand curves or in costs of trading to individual markets, and producers possess market power, firms are able to charge different prices for the same product in different countries. (Swift 2004) Krugman (1986) labeled this practice of third degree price discrimination as pricing-to-market (PTM). For a large economy, the price will not equal marginal cost anymore. Further, the law of one price may not hold as at least some degree of exchange rate pass-through into the domestic currency denominated price is possible. Several empirical studies (e.g. Naug and Nymoen 1996; Kongsted 1998; Swift 2001: Adolfson 2001) indicate that the PTM hypothesis is relevant also for small open economies, where export producers thus seem to have some market power and ability to affect prices (Adolfson 2001). In forest products trade this has been identified by e.g. Hänninen (1998a) and Hänninen and Toppinen (1999) for the small and open economy of Finland. Athukorala and Menon (1994) emphasize that the pricing-to-market phenomenon can be thought of as a strategic decision of the exporting firm, where the effects are essentially short-lived and mainly used for buying time until the firm is able to make other adjustment measures.

In addition to firms' strategic pricing behavior, exchange rate pass-through estimates intend to capture the natural change in prices brought about by cost changes. If these are significant, the ERPT coefficient will tend to be under-estimated as such cost changes naturally offset some of the exchange rate movements. (Athukorala and Menon 1994) In the present study a partial equilibrium framework is used, meaning that potential indirect feedback on trade prices from cost effects will be left aside and only the strategic behavior of exporting firms will be analyzed. This is due to the fact that forest industries in Finland and Sweden are fairly self-sufficient and thus input cost effects can be assumed to be minor regarding currency movements.

3.3.2.2 Choice of invoicing currency

The context of a small open economy is often perceived to be equivalent to local currency pricing (LCP) i.e. assuming the invoicing currency used is that of the importer's. This pricing strategy has been identified for example by Knetter (1992) in showing that the choice of contract currency will depend on the same factors, curvature of demand and cost functions, that determine pass-through in the long-run. Accordingly, as for small economies local currency prices are determined by the interaction of demand and supply thus affecting only home currency prices to fluctuate along with exchange rate movements, LCP would be preferred. Devereux et al. (2004) and Bacchetta and van Wincoop (2005) have also suggested that exporters have an incentive to stabilize the price in the currency of the customers in order to stabilize demand. Friberg (1998) has argued that when forward currency markets are introduced, pricing in the buyer’s currency and fully hedging the concomitant price risk is optimal behavior for an exporter in most circumstances.

If exporters, in turn, set the price in their own currency, then this is referred to as producer currency pricing (PCP). For example Devereux and Engel (2001) derive an analytical solution to the invoicing choice and show that countries with lower monetary volatility may prefer to price in their own currency. Goldberg and Tille (2008) report yet another possible choice, which is invoicing in a third, “vehicle”, currency (VCP). They note that especially industries with highly substitutable goods and low relative market shares among competitors have a strong incentive to coalesce in their invoicing choice. Therefore either LCP or VCP would be preferred. The far greater use of the dollar in trade invoicing than what would be expected purely on the basis of direct trade flows with the U.S is an indication of VCP.

An important notification is that the fundamental to the pass-through phenomenon in the short-run is different for the two distinctive pricing variations and therefore one need always to assure whether LCP or PCP is used. While most of the literature assumes exogenously that firms set prices either in their own currency or in that of the importer, in reality firms are not neutral between these choices. Swift (2001) points out that the invoicing decision will ultimately depend on the risk aversion characteristics of both buyer and seller. For example if prices are set in importer's currency (LCP) before exchange rates are realized, the exporter will still get the same amount of money in foreign currency and only the firm's profit margin will change. Thus, if firms set prices in the importer’s currency, we should expect zero pass-through, and uncertainty in the price denominated in the exporter’s currency, but no uncertainty in the demand. If prices are on the other hand set in the producer's home currency (PCP), an exchange rate change will only affect the foreign currency price i.e. the price the importer will have to pay in its own currency and the exporter's profits will stay constant. Full pass-through is hence expected when prices are set in the exporter’s currency, affecting the demand to be uncertain. (Bacchetta and van Wincoop 2005)

The possible contradiction of the ERPT phenomenon in the short run is driven by the assumption that prices are sticky and the exporting firm can choose its currency to keep its price closer to the desired price in periods when the firm does not adjust. In the long run, when prices adjust there is no difference in pass-through using LCP or PCP. Moreover, if prices are adjusted in every period, the choice of invoicing currency is irrelevant even in the short run. (Gobinath et al. 2007) Engel (2006) still remarks that finding prices that do not respond much to exchange rates is difficult to interpret either as support or contradiction for the notion that nominal prices are sticky: Export prices may respond very little to exchange rate changes even when firms are free to adjust their prices continuously. This describes just how multifold the whole pass-through phenomenon is, so that clear-cut interpretations about pricing strategies and the perceived degree of competition are often hard to make; there is always left some ambiguity in interpreting the results due to the underlying assumptions made about the specific trade conditions.

3.3.2.3 Measuring long-run exchange rate pass-through

The ERPT coefficient can be measured as a short and long run relationship between changes in exchange rates and export prices. The short run coefficient indicates the direct impact of exchange rate changes and the long run coefficient depicts the steady state equilibrium between currency changes and export prices. In theory, the value of the ERPT coefficient is closely related to the structure of the market providing information about the degree of competition in the market. The degree of pass-through is a function of the elasticity of demand and supply and it can be derived as the absolute value of the exchange rate elasticity of export price measured in foreign currency. In the present study this will be obtained from the price relation (3.9) by first converting the home currency price to foreign currency and then by taking a partial derivative with respect to the exchange rate, *er*: (e.g. Kongsted 1998; Hänninen 1998a)

$$\text{ERPT} = -(\partial(p_i - er / \partial er) = \gamma, \quad 0 < \text{ERPT} \leq 1, \qquad (3.11)$$

where γ measures the impact of exchange rate changes on the foreign currency export price for a given cost (and other explanatory variables) and can be therefore called the pass-through coefficient. The remaining of the exchange rate change, 1 - γ, will be shifted into the domestic currency price by adjusting the markup accordingly.

Two polar cases can be distinguished from (3.11) by following the "small open economy"-context, where non-constant elasticity of demand is assumed (Swift 2001). An ERPT value of zero ($\gamma = 0$) would indicate that producers do not possess market power to change the foreign currency price as a result of an exchange rate change. In (3.9) this would mean that only competitors' prices enter the price equation and changes in the exchange rate are fully absorbed by the variable markup. Thus, competition is perfect and the law of one price holds. For example, in case of home currency depreciation (appreciation) the foreign currency export price would remain constant and instead the producer's markup would change, increasing (decreasing) profits. This often occurs in situations where the cost proportion of imported materials is large and thus there is little room for altering the export price denominated in the importers currency. (Han and Suh 1996) If however the competition is imperfect and producers are able to vary the export price, the ERPT coefficient is between zero and unity. In the case where ERPT value is one ($\gamma = 1$), the home currency price stays proportional to production costs, implying that only foreign currency price had changed as a result of an exchange rate change keeping the markup constant. This could mean that depreciations have been used to lower the relative price of the exported product to gain price competitiveness and possibly increase market share. In case of currency appreciation, a high ERPT value could, on the contrary, imply that exporters are reluctant to decrease profit margins.

Posterior dynamic theories of exchange rate pass-through have extended the early imperfectly competitive models, arguing that exporters can maximize strategic advantage by varying pass-through over time (e.g. Baldwin 1988; Froot and Klemperer 1989). For example in the sunk-cost model it is hypothesized that irreversible costs could be hedged by absorbing even unfavorable exchange rate fluctuation for a set range. This could be due for example to reduce price variation for the importer. Only after the fluctuation moves outside this range will the exporting firms begin passing through the exchange rate change, at least partially; a structural break occurs in the relationship of the exchange rate and foreign currency price after the boundaries of the range are crossed. (Swift 2004) Some studies have also suggested that in practice there is asymmetry in pricing behavior of exporting firms between appreciations and depreciations of the exchange rates. Knetter (1994) has for example argued that if exporting firms face capacity constraints in their distribution networks, then currency appreciations of the importing country might cause lower pass-throughs than depreciations. According to Uusivuori (1990, pp. 19) an implication of this asymmetry in the global forest sector could be that forest sectors in individual countries are susceptible to inflationary pressure caused by currency movements. The pressure would naturally be the higher the more imported inputs are used in production.

Difficulties in measuring the magnitude of ERPT occur also in situations where currencies of other relevant suppliers change in the same direction as ones own currency. This makes it hard to isolate the exchange rate effect of one currency alone. Also timing of the responses to exchange rate changes might cause problems. In perfectly competitive markets depreciations first increase only markups and foreign currency prices remain steady. With time, the increased markup shifts the supply upwards which in turn lowers the world market price. ERPT value in this situation is over zero, although markets are perfectly competitive. (Uusivuori et al. 1997) According to Hänninen (1998b, p. 29) it is also possible to have an ERPT value of zero in imperfectly competitive markets. This could happen in situations, where long term contracts have been used to determine the foreign currency export prices months in advance. Only the profit margin would be affected and the effects of exchange rate changes could be adjusted to destination-currency prices only with a delay.

3.4 The EMU and competition

A characteristic of the Finnish economy has been that export demand fluctuations have greatly influenced business cycles (Hänninen 1999b). Devaluations were used in Finland all the way till the beginning of 1990's as a means to improve competitiveness of the export industry, when the domestic cost level rose too high compared to the competitors': the last currency realignment was used in 1991, when the the Finnish mark (FIM) was devalued by 10% (Mörttinen et al. 2001, p. 92). After Finland's joining of the European Monetary Union's third phase in 1.1.1999, the Finnish mark was merged into the euro at an irrevocable fixed rate and the birth of a common currency meant the elimination of exchange rate risks in EMU's internal trade. This has opened a whole new market for many small companies in the woodworking industry, previously serving only the domestic market. However, the increased competition resulting from fixing the FIM to the euro has also set a major challenge to these companies. Another downside effect has been that national economies are no longer able to use exchange rate adjustments to balance business cycles and improve competitiveness. (Hänninen 1999b; Hänninen 1998c) The following will report about the discussions on the implications of joining the monetary union, and what can be said on the basis of previous studies concerning the matter.

Importance of EMU as the home market for exports was assumed to be crucial consideration of the effects the union would have on the Finnish sawnwood industry. According to the optimum currency area (OCA) theory, entering a monetary union creates a positive effect from lower transaction costs for trade and a negative effect from losing the macro-economic insurance provided by a flexible exchange rate (Jonung and Vlachos 2007). Thus, the more Finland trades with other member countries, the greater the benefits will be. A study conducted by Bun and Klaassen (2002) reveals that the euro has indeed increased intra-EMU trade and that the magnitude of the estimated effects (40% increase in the long run) is substantial from an economic point of view. Hetemäki et al. (1997) stated, in turn, that EMU participation would not significantly affect the geographical distribution of forest products exports. Exports will be directed, in addition to the euro zone, more and more at countries outside the EMU region where the growth of forest products consumption is higher. This was also noticed in the previous chapter, where Finnish sawnwood exports to Germany were shown to have been declining for the past years, whereas exports to e.g. Japan have been increasing from the end of 1990s.

Another decisive factor, causing uncertainty on the consequences of EMU participation, is that some important competitor and customer countries have stayed outside the monetary union. For example one of the most important competitors of the Finnish sawnwood industry, Sweden and one of the main sawnwood importers, UK, have decided to keep their own currencies, at least for time being. Broad use of the krone as a pricing currency in international trade could give an advantage to Swedish sawnwood exporters. Hetemäki et al. (1997) have emphasized that a weak krone could be a problem for Finnish sawnwood exporters at least in the short-run. The paper industry has earlier prepared for the monetary union with precautions, for example by strengthening its balance sheets, acquiring production capacity from inside and outside the EMU region and increasing unit sizes (Hänninen 1999b). Still, any major exchange rate adjustments are probably unlikely in Sweden as the central bank, Riksbank, is aiming for a credible economic policy and low inflation, which demands a stable exchange rate policy. Indeed, Brissimis and Kosma (2005) point out that the adoption of the euro has caused a structural shift in the market conditions non-euro area exporters face, in the sense that the number of their competitors that are exposed to exchange rate changes has been reduced significantly. Therefore, in anticipation of this change and in order to safeguard their presence in euro area markets and be less vulnerable to exchange rate changes, non-euro area exporters are likely to have been reconsidering their pricing and innovation strategies.

The EMU's influence on Finnish sawnwood industry also depends on what the euro's share as an invoicing currency is. Brissimis and Kosma (2005) have noted that with adoption of the single currency, what matters for firms' invoicing decisions is the market share of the union as a whole and not that of individual countries; therefore, in general, producer currency pricing is likely to emerge as the dominant invoicing strategy by euro area exporters. Also Hartmann (1998) advises that monetary network effects tend to favor the emergence of the euro as a major invoicing currency. Hänninen et al. (2000) have, however, suggested that as the Swedish krone and US dollar have traditionally played a significant role as pricing currencies in international sawnwood trade, the introduction of the euro would most likely not have a significant effect on this. Nevertheless, which ever invoicing strategy is chosen (LCP, PCP or VCP) and although exchange rate risks in euro based internal EMU trade do not exist anymore, the risks will naturally prevail in trade with non-member countries. Hence, a key issue is how the value of the euro develops in relation to other currencies and what kind of exchange rate policy the European Central Bank (ECB) and Finland's competitors outside the monetary union have and will continue to employ.

As reported in the introduction, previous studies (e.g. Hänninen 1998a) have indicated high values of exchange rate pass-through for Finnish sawnwood exporters. This means that devaluations have been used as a means to improve price competitiveness and increase market share, rather than a remedy for profitability. Increased exports have however raised utilization ratios and hence together with higher revenues the markup and profits have increased. As a result the Finnish forest industry has not had to bear all of its operative risks. The positive impact of devaluation however vanishes fairly quickly into input prices and the main reason for the advantages has been that the devaluations have occurred quite regularly. A high ratio of domestic inputs in sawnwood industry has also meant that the total cost of production has raised only a little on account of devaluation hence making it possible to lower the end product price. This in turn could imply increasing price pressures in the sawnwood industry and adapting to the EMU being problematic. (Hetemäki et al. 1997)

4. DATA AND ESTIMATION METHOD

4.1 General

This chapter will present the data and estimation method used in the study. In addition, a short description of the main concepts arising from the estimation and analysis process will be given. Economic time series have certain properties, which need to be analyzed before estimation and therefore it is relevant to clarify these first, before moving on to the description of the actual method employed.

The starting point will be the analysis of a single time series. The purpose of this is to exploit the information that can be obtained from a variable that is available through systematic variation of the variable itself. In this section, the concept of stationarity and unit root will be explained together with autoregressive (AR) models. Single time series can potentially create major problems in empirical econometrics due to spurious regressions and for this reason multivariate time series models have been developed. This will be the topic of the latter section in which the Johansen cointegration method, applied in the present study, will be introduced in a vector autoregressive (VAR) model framework.

4.2 Concepts

4.2.1 Stationarity in a univariate framework

Traditional methods in econometric time series theory rely on a set of assumptions concerning the stochastic properties of the time series analyzed; a key concept being that of stationarity. Time series are often assumed to be (weakly) stationary, implying that the first moments of the series are invariant in time, at least when some deterministic trend has been filtered out of the data. (Helles et al. 1999) In its simplest terms a time series is said to be stationary if its mean (4.1), its variance (4.2) and its covariances (4.3) remain constant over time (Asteriou and Hall 2007, p. 231):

$$E(y_t) = E(y_{t-s}) = \mu \qquad (4.1)$$

$$E[(y_t - \mu)^2] = E[(y_{t-s} - \mu)^2] = \sigma_y^2 \qquad (4.2)$$

$$E[(y_t - \mu)(y_{t-s} - \mu)] = E[(y_{t-j} - \mu)(y_{t-j-s}\mu)] = \gamma_s, \qquad (4.3)$$

where μ, σ_y^2 and γ_s are constants. Many economic time series however do not satisfy this constancy condition; rather they may have permanent time-dependent, stochastic and/or deterministic, components and belong to a class of nonstationary processes, which need transformation to attain a stationary series. (Enders 2004, p. 164)

Although a series that is tending to grow over time cannot be stationary, the changes in that series might be. As a reaction to this, Box and Jenkins (1976) proposed a system of modelling which involved pre-filtering all data to render it stationary before proceeding to estimate. If for example a nonstationary series becomes stationary after differencing it once, it is said to be integrated of order one ($I(1)$). A stationary series in levels (without differencing) is said to be integrated of order zero ($I(0)$). This brings on to the definition of integration: a series which has a stationary, invertible, non-deterministic ARMA representation after differencing d times, is said to be integrated of order d, denoted $x_t \sim I(d)$. Such a nonstationary series is also termed homogenous and the amount of times the series has to be differenced to become stationary implies the number of unit roots of the series. (Engle and Granger 1987) Formally, the inspection of a unit root can be presented with an AR(1) model:

$$y_t = \phi y_{t-1} + e_t, \tag{4.4}$$

where $E[e_t] = 0$ is a white-noise process and the stationarity condition is $|\phi| < 1$. The series explodes if $|\phi| > 1$ and when $\phi = 1$ the series contains a unit root and is nonstationary. In this case subtracting y_{t-1} from both sides of equation (4.1) we get:

$$y_t - y_{t-1} = y_{t-1} - y_{t-1} + e_t \qquad = \Delta y_t = e_t \tag{4.5}$$

and because e_t is a white-noise process then we have that Δy_t is a stationary series (Asteriou and Hall 2007, p. 288 - 290).

Stationarity is an important condition in time series analysis, because if the series is nonstationary then all the typical results of the classical regression analysis are not valid. This was formally identified by Granger and Newbold (1974) in a Monte Carlo simulation of nonstationary series. They coined the term *spurious regression* for the results obtained by using two trended and independent variables in a regression when the variables were actually unrelated. The results indicated significant relationships between the variables with high R^2s. They also found that the Durbin-Watson (DW) statistics were very low indicating high degree of autocorrelation of residuals. This implication of nonstationary processes is very important as many economic series contain an underlying rate of growth. Moreover, effects of shocks will not dissipate and the series will not revert to its long-run mean level in time as in stationary time series. (Asteriou and Hall 2007, p. 291; Enders 2004, p. 164) To avoid the problem of spurious regression, testing for the presence of unit roots and or/deterministic trends needs to be carried out. The method employed in this study was developed first by Dickey and Fuller (1979, 1981). Key insight of the Dickey and Fuller (DF) procedure is that testing for nonstationarity is equivalent to testing for the existence of a unit root ($H_0 = I(1)$). Dickey and Fuller (1979) consider three different regression equations that can be used for the testing:

$$\Delta y_t = \gamma y_{t-1} + e_t \qquad (4.6)$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + e_t \qquad (4.7)$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + e_t, \qquad (4.8)$$

where $\gamma = \phi - 1$ (see above equation 4.4) and the disturbance term, e_t, is an independent and identically distributed (IID) process. The three equations differ in terms of the deterministic elements a_0 and a_2t; the first equation (4.6) is a pure random walk model, the second (4.7) adds an intercept, and the third (4.8) includes both an intercept and a linear time trend. The choice for what regression to use depends on the true data-generating process of the tested series (Rao 1994, p. 57 - 58). As shown in equations (4.4) and (4.5) the condition for nonstationarity in an AR(1) process is obtained when $\phi = 1$. This is equivalent to the null hypothesis, H_0: $\gamma = 0$, of nonstationarity in the DF procedure. The DF-test statistic is a normal 't' statistic for the lagged dependent variable. However, as this test does not have a conventional 't' distribution, special critical values calculated by Dickey and Fuller are used. If the DF statistical value is larger in absolute terms than the critical value then we reject the null hypothesis and conclude that y_t is stationary. The test statistics, critical values and the alternative hypothesis of stationarity depend on the form of the regression equation (Asteriou and Hall 2007 p. 295-296; Enders 2004, p. 182-183).

If the assumption of an IID process is incorrect, then the limiting distributions and critical values obtained by the DF procedure cannot be assumed to hold. However, Dickey and Fuller (1981) were able to demonstrate that the values obtained under the assumption of an IID process are in fact also valid when e_t is autoregressive if the augmented Dickey Fuller (ADF) regression is applied. It was suggested that by including extra lagged terms of the dependent variable autocorrelation can be eliminated. Thus, it is possible to use the Dickey-Fuller tests in higher order equations using a *p*th-order autoregressive process:

$$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \ \dots + a_{p-2} y_{t-p+2} + a_{p-1} y_{t-p+1} + a_p y_{t-p} + e_t, \qquad (4.9)$$

where e_t now defines an IID process. The lag length on these extra terms can be determined, in addition to F-tests and t-tests, by different criterions (Akaike Information Criterion (AIC), Schwartz Bayesian Criterion (SC) etc.), or more usefully by the lag length necessary to whiten the residuals. In practice, the SC will select a more parsimonious than will either the AIC or t-tests. Nevertheless, the main consideration is to ensure white-noise processes (Enders 2004, p. 189-193). Now the three possible regression forms for testing are given by the following equations:

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + e_t \qquad (4.10)$$

$$\Delta y_t = a_0 + \ \gamma_{yt-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + e_t \qquad (4.11)$$

$$\Delta y_t = a_0 + \gamma yt_{-1} + a_2 t + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + e_{t,} \qquad (4.12)$$

The difference between the equations (4.10 – 4.12) again concerns the presence of the deterministic elements a_0 and a_2t. The null hypothesis is the same as in the DF test, as well as the critical values and the test statistics (Asteriou and Hall 2007, p. 297; Rao 1994, p. 61).

Although testing of stationarity may seem straightforward, there are several issues weakening the power of the test results. One serious problem relates to the fact that the tests are not able to distinguish between a unit root and a near unit root process on moderately sized samples; a trend stationary and an $I(1)$ process will have the same shaped autocorrelation function (ACF) for finite t (Banerjee et al. 1993, p. 95). However, Enders (2004, p. 208-210) stresses that this is not always a problem as a trend stationary process can arbitrarily well approximate a unit root process (and vice versa) by being long-memoried and thus short-run forecasts from the alternative models may have nearly identical forecasting performance.

A weakness of unit root tests related to the fact that the true data generating process is not known is often more problematic as this makes the regression form to use somewhat arbitrary. First, the true order of the autoregressive process is usually unknown to the researcher, so that the problem becomes selecting the appropriate lag length. Introducing a sufficient number of lags usually produces a well-behaved disturbance term so that the parameter γ and its standard error can be assumed to be well estimated. At the same time, however, the power of the test to reject the null of a unit root decreases as this necessitates the estimation of additional parameters and degrees of freedom are lost. Also adding irrelevant regressors or omitting parameters belonging to the actual data-generating process will reduce the power of the tests. (Enders 2004, p. 191-192, 211) Selecting the appropriate model specification regarding deterministic components relates to this problem, as it is often not clear if an intercept and/or a time trend should be included in the model. As the regression form defines the critical values and the proper test statistic to be used, by using a form not in compliance with the true data-generating process, one might make false interpretations of the stationarity of the series. Yet another problem arises from structural breaks in the time series. According to Enders (2004, p. 200) this will bias the test result toward the non-rejection of a unit root.

The point is that it is important to use a regression equation that mimics the actual data-generating process. Economic theory can aid in the process of choosing the appropriate model to use. Also graphical presentation and visual inspection of data is often recommended as this might give information about the deterministic components of the underlying data-generating process. It has also become increasingly common not to rely too heavily on pre-testing of variables for their orders of integration before considering the relationship between them in a cointegration framework (Rao 1994, p. 71).

4.2.2 Cointegration and vector autoregressive (VAR) models

As presented in the previous section, in univariate models a stochastic trend can be removed by taking differences of the integrated time series. The resulting stationary series can then be estimated using standard econometric methods as demonstrated by the Box-Jenkins (1976) methodology. This approach however has a significant drawback as important information could be lost in the pre-filtering stage and long-run properties of the data, in particular, are being completely ignored. Indeed, now it is recognized that the appropriate way to treat nonstationary data in a multivariate context is not as straightforward. (Enders 2004, p. 319) Before moving on to this, the statistical analysis of nonstationary data will be shortly represented in a multivariate context with vector autoregressive (VAR) models. This is in many ways equivalent to the presented univariate case above, but as it is the building block for the applied method in this study it will be introduced separately.

The basic idea behind a vector autoregressive model is to capture the evolution and interdependencies between multiple time series, generalizing the univariate (AR) models. Further, all the variables in a VAR are treated symmetrically as it is often unknown that a variable is really exogenous. To illustrate a vector autoregressive model consider the n-dimensional stochastic process X_t with a k-order autoregressive representation:

$$X_t = \Pi_1 X_{t-1} + ... + \Pi_k X_{t-k} + \Phi D_t + \varepsilon_t, \quad t = 1,..., T, \qquad (4.13)$$

for fixed values of $X_{-k+1},..., X_0$ and IID errors $\varepsilon_t \sim$ NID $(0, \Omega)$. The deterministic terms D_t can contain a constant, a linear term, seasonal dummies, intervention dummies, or other regressors considered to be fixed and non-stochastic. This is called a VAR - process and the characteristic polynomial for this is given by:

$$A(z) = I - \sum_{i=1}^{k} \Pi_i z^i = I - \Pi_1 z, \qquad (4.14)$$

when $k = 1$ and where z can be a complex number. Assuming that A(z) satisfies the condition that if |A(z)| = 0 then |z| > 1 or z = 1, and by this excluding explosive roots as well as seasonal roots with |z| = 1. This implies that the roots of |A(z)| are just the reciprocal of the non-zero eigenvalues of Π_1. In this case the solution of equation (4.13) is given by:

$$X_t = \Pi_1^t X_0 + \sum_{i=0}^{t-1} \Pi_1^i (\varepsilon_{t-1} + \Phi D_{t-1}), \tag{4.15}$$

and the eigenvalues of Π_1 are all inside the unit disk or precisely at the value 1, when k = 1 as Π_1 is then identical to the companion matrix of the process. This means that the coefficients Π_1^i tend to zero exponentially fast and hence that the linear process is well defined as a stationary process. The variance of X_t:

$$Var(X_t^*) = \sum_{1=0}^{\infty} \Pi_1^i \, \Omega \, \Pi_1^{i'}, \tag{4.16}$$

is finite since the eigenvalues of Π_1 are inside the unit disk, implying that X_t is convergent with probability 1. In contrast, if A(z) has a unit root so that A(1) = 0, then Π must also have an eigenvalue equal to 1, implying that Π_1^i does not decrease exponentially as i increases. Hence, the process governing X_t does not converge as it becomes the sum of past stochastic shocks, indicating an integrated process and need for "detrending" before estimation. (Helles et al. 1999; Johansen 1995, p. 11-14)

This is however not always the case. It was represented by Granger (1981) that if there exists a linear combination between series, these may have a lower order of integration than any one of them has individually. The question of stationarity of series can then be formulated in terms of parameters in a multivariate system, and is a hypothesis that is conveniently checked inside the model rather than a question to be answered prior the analysis (Johansen 1995, p. 74). When this linear relationship occurs, a very special constraint operates on the long-run components of the nonstationary series linking their stochastic trends together. This concept is known as cointegration and was formally defined by Engle and Granger (1987) as follows: the components of the vector X_t are said to be cointegrated of order d, b, denoted $X_t \sim CI(d,b)$, if all components of the vector are integrated of order d $(I(d))$ and there exists a vector β ($\neq 0$) so that $X_t = \beta' X_t \sim I(d-b),\ b > 0$; the vector β is then called the cointegrating vector.

An important implication of the above definition is that if two variables are integrated at different orders of integration then these two series cannot possibly be cointegrated. The error term itself will generally be integrated at the highest order of any of the variables in the regression and the basic assumption of OLS will be violated. It is however possible to have different order series when there are more than two series under consideration. In this case a subset of the higher order series must cointegrate to the order of the low order series. (Hall and Henry 1988, p. 53-54) Also other implications have been raised (e.g. Enders 2004, p. 322-333): i) cointegration refers only to a linear combination of nonstationary variables although nonlinear long-run relationships are also possible among a set of integrated variables; ii) if x_t has n components, there may be as many as n-1 linearly dependent cointegrating vectors, referred to as the cointegration rank of X_t. Yet, probably the most important result of the definition of cointegration is the Granger Representation theorem (Granger 1983) showing that if a set of variables are cointegrated then there exists a valid error-correction representation of the data. This can be presented actually as a multivariate version of the ADF-test regression shown above:

$$\Delta X_t = + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \mu + \Phi D_t + \varepsilon_t, \qquad (4.17)$$

Again it is assumed that $\varepsilon_t \sim$ NID $(0, \Omega)$ and where Γ_i, ..., Γ_{k-1} and $\Pi = -I + \Pi_1 + ... + \Pi_k$ are coefficient matrices. If X_t is $I(0)$ then any autoregressive representation can be written in error-correction form. On the other hand, if X_t is $I(1)$, then the n x n coefficient matrix Π is expected to be the null matrix, because the levels of X_t are of higher stochastic order than the differences of X_t. In a multivariate framework there may, however, be stationary linear combinations between the elements of X_t so that an error-correction representation can be given. Then X_t must be cointegrated and some matrix of cointegration vectors β' must exist. Estimating X_t as a VAR in first differences would be inappropriate in this case and would entail a misspecification error if an error-correction representation could be given. Yet, if all elements of Π equal zero, equation (4.17) is a traditional VAR in first differences as ΔX_t would not respond to the previous period's deviation from the long-run equilibrium. (Enders 2004, p. 330)

As already pointed out, a principal feature of cointegrated variables is that their time paths are influenced by the extent of any deviation from the long-run equilibrium. In an error-correction model (ECM), the short-term dynamics of the variables in the system are influenced by this deviation from the equilibrium. This can be shown by reformulating the error-correction relation (4.17). If all the components of X_t are assumed to be $I(1)$ cointegrated processes and the number of cointegration relations is r, then the n x n matrix Π has a reduced rank r and can be given the representation $\Pi = \alpha\beta'$, where α and β are n x r matrices of full rank. Now the error-correction model can be presented as (Helles et al. 1999; Johansen 1995, p. 39):

$$\Delta X_t = \alpha\beta' X_{t-1} + \mu + \varepsilon_t, \qquad t = 1, ..., T. \qquad (4.18)$$

The matrix β contains the r cointegrating vectors, so that $\beta' X_t$ is an r-dimensional stationary process and measures the disequilibrium at any point of time. The matrix α contains the so-called adjustment coefficients, measuring the impact that disequilibria have on current changes in the variables. Thus, the dynamics of both short-run, as given by the lagged differences, and long-run, as described by the stationary cointegration relations, adjustment processes are modeled simultaneously in an ECM. This offers the possibility to reveal information about both short-run and long-run relationships, which is an essential feature of the ECM in general. (Banerjee et al. 1993, p. 139-140; Helles et al. 1999) As the present study is interested in separating long-run exchange rate effects from the short-run effects, the error-correction form was therefore applied. The applied estimation procedure will be presented next in more detail.

4.3 Estimation method

There are two main approaches on the estimation of cointegration relations; the single equation and the system approach. Engle and Granger (1987) introduced the most common single equation approach, which has been applied in some past studies modelling international trade (e.g. Uusivuori and Buongiorno 1991; Buongiorno and Uusivuori 1992; Menon 1993b; Athukorala and Menon 1994, 1995; Kim et al. 2003), but to a lesser extent used in the more recent studies. This is due to a considerable shortcoming of this and other single-equation methods, that it is not able to estimate more than one cointegrating vector at a time. This means that when a cointegrating relationship was found, it was assumed to be unique. In this study, however, a demand and price equation system will be applied; it is assumed that the price equation (3.9) and the export demand equation (3.3) are derived simultaneously implying that two cointegrating vectors were to be found if there exists a linear long-run relationship between the variables in question. (e.g. Kongsted 1998; Hänninen 1998a) The uniqueness condition can thus be relaxed. Estimating with the Engle-Granger method, one would get invalid results if there were more than one cointegrating vector. According to Hänninen (1998a) the relationship may simply represent complex linear combinations of all the cointegrating vectors in this case.

4.3.1 Johansen's cointegration method

In this study these conventional methods were replaced by Johansen's cointegration method (1988), further developed by Johansen and Juselius (1990, 1992). It provides a log-likelihood ratio test statistic for determining the number of cointegrating vectors in the data and is therefore applicable for multiple equations. Another advantage of this method is that it enables to test hypotheses in a simultaneous multivariate framework. It also accommodates short-run dynamics in the cointegration regression, unlike the Engle-Granger method, which helps to reduce biases and improve efficiency in using the information content of the data in the estimation. (Hänninen 1998a) Majority of the more recent studies have applied the Johansen's methodology in modelling forest products' export price formation and trade (e.g. Sarker 1996; Alavalapati 1997 et al.; Hänninen 1998a; Hänninen and Toppinen 1999; Jee and Yu 2001; Sun and Zhang 2003; Hänninen et al. 2007; Nagubadi et al. 2009).

Before proceeding to the actual estimation, the variables were tested for nonstationarity using ADF tests. This is not a necessity for the applied method as one can include in the cointegration analysis variables that are considered meaningful as long as they are $I(1)$ or $I(0)$. However, by including a stationary variable in the vector X_t an extra cointegrating vector, that is, an extra dimension is added to the cointegration space. (Johansen 1995, p. 74) This will affect the results given by the cointegration rank and therefore the single time series were tested prior estimation.

The basic model used in the Johansen procedure is the unrestricted vector autoregressive (VAR) model (equation 4.13) with independent Gaussian errors. The estimation of cointegration relations is initiated by estimation of the reduced form error-correction model as defined in equation (4.17), where ΔX_t is an $I(0)$ vector of the six first-differenced variables (Johansen 1995, p. 89):

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} +,..., + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha\beta' X_{t-k} + \mu + \Phi D_t + \varepsilon_t \quad t=1,..., T, \quad (4.19)$$

where ε_t are independent Gaussian errors with mean zero and variance Ω, and (α, β, Γ_i, ..., $\Gamma_{k-1,}$ Φ, Ω) are freely varying parameters. D_t represents a seasonal dummy and k is the appropriate lag length chosen through diagnostic testing of the residuals of individual equations and by using the Hannan-Quinn (HQ) and Schwarz (SC) information criteria. The interpretation of the constant term, μ, is important as the asymptotic distribution of the test statistics and estimators depend on the assumption made (Johansen 1991, p. 6). In the absence of a linear trend in the data the constant term can be restricted to the cointegration space in a VAR model. In the present study the inclusion of deterministic terms was solved for each of the models separately as demonstrated by Johansen (1992a).

The estimated error-correction model is actually a traditional first differenced VAR-model except for the term $\alpha\beta' X_{t-k}$. This is not surprising, as the main purpose of the transformation to an error-correction form is to investigate the coefficient matrix Π = $\alpha\beta'$ as to the information it may convey concerning the long-run information in the data. (Johansen 1991, p. 2) Indeed, the first step in the Johansen procedure is to remove the effect of the short-run dynamics by regressing ΔX_t and ΔX_{t-1} on the lagged differences ΔX_{t-1}, ..., ΔX_{t-k+1} and D_t. The residuals R_{0t} and R_{1t} obtained can then be used to formulate a regression equation in residuals for cointegration estimation (Helles et al. 1999; Johansen 1995, p. 90-91):

$$R_{0t} = \alpha\beta' R_{1t} + \hat{\varepsilon}_t . \quad (4.20)$$

This is a reduced rank regression and it is equivalent to the concentrated likelihood function from where the rank of the coefficient matrix Π = $\alpha\beta'$ can be solved. The number of cointegrating vectors is determined by estimating this rank order. As pointed out earlier, if the rank of the matrix Π is zero, no cointegration exists between the variables and the VAR model in differences with no long-run elements would be the appropriate model to use. When the rank is one, there is a single cointegrating vector and for cases in which $1 < \Pi < n$ there are multiple cointegrating factors. In each of these cases differencing would lead to a specification error, implying that an error-correction form should be applied. To test for the number of cointegration vectors in the set of variables, Johansen has formulated two likelihood ratio tests; the trace test and the maximum eigenvalue test. The null hypothesis in the trace test can be expressed as H_0: $\Pi \leq r$ which is equivalent to H_0: $\Pi = \alpha\beta'$. This means that the trace test tests the hypothesis that the n-r smallest eigenvalues are zero against the alternative hypothesis that all eigenvalues are different from zero (Helles et al. 1999). The test statistic can be expressed as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln(1 - \hat{\lambda}_i), \qquad (4.21)$$

where T is the number of usable observations and λ_i's are the smallest squared canonical correlations, also called eigenvalues ($\hat{\lambda}_1 > \hat{\lambda}_2 > \ldots \hat{\lambda}_n$), obtained from the estimated matrix Π between the residual vectors R_{0t} and R_{1t}. The maximum likelihood cointegration relations are given by the eigenvectors $\hat{V} = (\hat{v}_1, \ldots, \hat{v}_n)$, which are often normalized by $\hat{V}'S_{11}\hat{V} = I$. The resulting ML estimators of $\hat{\beta}$ given by $\beta = (\hat{v}_1, \ldots, \hat{v}_r)$ correspond to the r largest eigenvalues after corrected for lags and deterministic terms. (Johansen 1991, 1995, p. 92-93) The estimators of the other parameters are obtained by regressing $\hat{\beta} = \beta$ with the ordinary least squares method. However, an important point is that one can only estimate the cointegration space spanned by β and the space spanned by α; the parameters α and β can not be estimated directly as they form an overriding parameterization of the model. This means that an economic interpretation can not be given until an identification of the cointegrating vectors has been made (Johansen 1988). This is obvious for the case where there exists only one cointegrating vector ($r = 1$) and where estimation of a single coefficient has no meaning, but the ratio of the two coefficients is in interest.

The situation is somewhat more problematic when there are two or more cointegrating vectors as in the present study. (Johansen and Juselius 1990; Johansen 1991)

The trace test proceeds in a sequence, where the number of cointegrating vectors selected is $r + 1$ and where the last significant statistic rejects the hypothesis of n-r unit roots. Alternatively, tests for the significance of the largest eigenvalues can be given by the maximal likelihood statistics, often denoted the maximum eigenvalue test (Johansen 1995, p. 93):

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}). \qquad (4.22)$$

The null hypothesis is the same as in the trace test, but the alternative hypothesis is now that $n - r + 1$ eigenvalues are zero. Both of the ratio test statistics (λ_{trace} and $\lambda_{\max}$) have non-standard (χ^2) asymptotic distributions, but are functionals of multivariate Dickey-Fuller processes. Critical values have also been tabulated by Johansen (1988), and Johansen and Juselius (1990) for a range of values n. (Banerjee et al. 1993, p. 267 - 268) In order to control the size of the tests, Johansen (1992a) suggests a testing procedure for determining the cointegration rank according to which the null hypothesis is rejected only if all sub-hypotheses, $\Pi < r$, can be rejected.

The decision for which test to use is somewhat arbitrary as there exists no simple rank order for the power of the distinctive tests. Basically this ambiguity is due to the low power in cases when the cointegration relation is fairly close to the nonstationary boundary (Johansen and Juselius 1992). Reimers (1992) concludes that the procedure tends to reject the null when it is true as the critical values may be only indicative because the asymptotic distributions are approximations to the true distributions. Cheung and Lai (1993) report Monte Carlo simulation results indicating that the trace test is more robust than the maximum eigenvalue test to possible non-normality of residuals. Doornik et al. (1998) also emphasize that λ_{trace} is often preferred as it has a consistent rank-selection procedure, known as Pantula principle (Johansen 1992a), and these tests are asymptotically similar with respect to the parameters related to the deterministic components. Enders (2004, p. 354) claims instead that $\lambda_{\max}$ has the sharper alternative hypothesis and it is usually preferred for trying to pin down the number of cointegrating vectors. Most of the times the results are equivalent for both tests, at least for large samples, so that one may choose either one of the tests to use. Also economic theory often provides the expected number of cointegrated relations, so that the hypotheses to be tested about the number of cointegrated relations can be determined in advance. In the present case the final decision of the number of cointegrating relations is based both, on results of the formal testing and interpretability of the obtained coefficients, as well as visual inspection of the cointegration graphs.

After determining the number of cointegrating vectors one can test hypotheses on the unrestricted model, conditional on r, by imposing linear restrictions on the matrix of cointegration vectors, β, and the loadings, α. This corresponds to investigating *a priori* theories about the cointegrating vectors and about their roles in different equations. (Banerjee et al. 1993, p. 276) The main point in testing these hypotheses is that if there are r cointegrating vectors then only these r linear combinations of the variables are stationary and all other combinations nonstationary. Thus, if the imposed restrictions are not binding, the number of cointegrating vectors will not diminish (Enders 2004, p. 355). The tests are all of likelihood ratio tests, where the model *(4.19)* is estimated with and without the restrictions and the statistics are calculated as a ratio between the two models. The asymptotic distributions of the test statistics are χ^2 distributions and the degrees of freedom are determined as the difference between the number of free parameters of the two models. (Helles et al. 1999)

Johansen (1995, p. 106-112) has provided a general formulation on how to set hypotheses on the cointegration vectors, β. The cointegrating relations are assumed to satisfy the restrictions $\beta_i = H_i \varphi_i$ for some s_i vector, that is,

$$\beta = (H_1\varphi_1, \ldots, H_r \varphi_r), \qquad (4.23)$$

where the design matrices H_i (p x s) are known and express linear economic hypotheses to be tested on each cointegration relation. φ_i are unknown matrices of dimension (s x r), containing the vectors of parameters to be estimated in the i'th cointegration relation. This formula relies on the assumption that the restrictions are actually identifying. However, in some cases one might want to test restrictions which are not identifying, i.e. the hypotheses do not depend on any normalization of the parameter β. These have been discussed by Johansen (1988) and Johansen and Juselius (1990, 1992) in more detail and are presented next as applied in the study.

$$\beta = H\varphi \text{ or } (\Pi = \alpha\, \varphi' H') \qquad (4.24)$$

where the matrix H (p x s) is known and defines the linear restrictions on parameter β. The same (p - s) linear restrictions are formulated on all the cointegrating relations r which in effect reduce the parameters of the unknown matrix φ to (s x r), where $r \leq s \leq p$. The alternative hypothesis for the above restrictions is the hypothesis $\Pi = \alpha\beta'$, where Π is unrestricted. The test statistic is asymptotically distributed as χ^2 with $(p - s)r$ degrees of freedom. This type of restriction can be used for example to test whether the coefficients of two variables add up to zero. In the present study, this hypothesis was first applied to test for price homogeneity by restricting the export price, p_i, and other nominal variables accordingly. Also the exclusion of a variable from the cointegration relation ($\beta_{ij} = 0$) was used to identify the long-run economic relationships of the export demand equation (3.3) and the price equation (3.9). Lastly, the assumption of the mark-up, c_i, was tested in the price relation by restricting it either to unity or zero, depending on the obtained unrestricted value.

Demonstrated by Johansen (1992b), a similar formulation is possible for identifying short-run dynamics by setting hypotheses on the loadings, α. This can be represented as follows:

$$\alpha = A\psi \text{ or } (\Pi = A\psi\beta') \qquad (4.25)$$

where the matrix A (p x m) is known and defines the linear restrictions on the parameters α, and ψ is a (m x r) matrix of parameters reduced by means of A, where $r \leq m \leq p$. Now it is assumed that the cointegrating relations have been properly identified and estimated, and that one wants to proceed to identify the short-run dynamics for fixed values of the long-run coefficients, β. This is equivalent for testing of weak exogeneity with respect to the long run parameters and is an essential requirement for efficient estimation of a conditional model. α_{ij} measures the weight by which each cointegrating vector, β_j, enters each of the *i*'th equation in the system and weak exogeneity implies that all the elements of the *l*th row of α are zero. Thus, the linear restrictions on α can be seen more as a conditioning whereas restrictions on β imply a transformation of the process. The weak exogeneity hypothesis was applied in the present study by initially restricting the adjustment coefficients alone and then confirmed, if needed, by tests of joint hypotheses that include the previously accepted restrictions on the long-run parameters in combination with proposed restrictions on α. Where the joint restrictions were not rejected, the model was conditioned on the weakly exogenous variables, and the partial system re-estimated to improve stochastic properties (Johansen 1992b; Johansen and Juselius 1992)

4.4 The data

The data of the present study consists mainly of the quantities and unit prices of the two main supplier countries, Finland and Sweden, in their sawnwood imports into the United Kingdom and Germany. The observation period is based on monthly data from the beginning of 1995 to the end of 2008. The main criterion for the chosen time period was the purpose of the study. Additionally, the estimation method restrains condtions for the overall length of the observation period through the number of total observations needed for reliable estimation results. As the objective is to study the effects of EMU, and for the time being this time period alone is still quite short for estimation purposes, it would be desirable that the period needed to be used before the foundation of EMU would be fairly well in compliance with the time after joining the union. Indeed, we can expect this to be quite true as the Finnish mark (FIM) was added into the European Exchange Rate Mechanism (ERM) in 1996 to reduce exchange rate variability and achieve monetary stability in preparation for EMU. Mayes and Virén (2009) also suggest that a change in behavior of EMU participants occurred around 1996 when member states were trying to converge under stage 2 of EMU and conclude the trend having continued thereafter. Also, as the economic development at late 1980's and the beginning of 1990's was very turbulent, especially in Finland where the FIM was changed by specific decisions several times, extending the period too far back could have biased the results. For the other end of the observation period, the only matter was to extend the post-transition period as far as possible to extract all available information from the effects of joining the European Monetary Union.

The data on import quantities and values were gathered from the statistics database, Eurostat. The product code used for coniferous sawnwood with the export trade CN-classification is 4407 10, which comprises 14 different sub products altogether. The import values are CIF figures, meaning that they contain cost, insurance and freight. The unit values were calculated by dividing import values (in EUR) with the corresponding import quantities (m^3). The values were not further deflated to obtain real unit prices, rather they were kept nominal. The competing countries' unit value (P_o) for each data point was calculated by taking a weighted average unit price according to total imports of the three most important competing countries and the remainder countries as a whole. In the UK market the main competitors of Finnish and Swedish sawnwood exporters (in addition to each other) come from Latvia and Russia. In Germany the corresponding countries are Russia and Austria. In order to obtain the home currency prices (P_i) for Sweden (SEK/m^3) in the UK and Germany and the competitors' prices in the UK (GBP/m^3) the import unit values were converted using the average nominal exchange rates (ER) accordingly. For Finland, the prices were already denominated in home currency (EUR). The exchange rates were obtained from databases of the Research Institute of the Finnish Economy (ETLA) and the Swedish National Bank, the Riksbank. Production costs of sawnwood (C_i) were described by production price indices (2000 = 100), which were obtained for Finland from Statistics Finland (Bulletin of Statistics) and for Sweden from Statistics Sweden.

After the original data was gathered it was transformed into unadjusted quarterly time series, to smoothen the effects of (monthly) outliers on the estimation of the models. Hence, each data set will comprise 56 observations in the estimation. For the import quantity variables (X_i and X_o) this was done by summing the respective months' quantities. Nominal exchange rates (ER), unit prices (P_i and P_o) and costs (C_i) were converted into quarterly data series by taking an arithmetic average from the appropriate months' values. Before estimation, the data was further transformed into logarithms on ground of the applied Johansen method. Also many nonlinear problems of parameter estimation can be made linear for taking logarithms of the dependent and independent variables as new variables. Proportional variations in the values are often more meaningful than absolute ones as well. Finally, it should be noted that, since all variables are converted to natural logarithms, the estimated coefficients could be interpreted as elasticities (Baek 2007).

The empirical variables chosen in the present study were based on previous similar studies (e.g. Hänninen 1998a; Kongsted 1998) and availability of relevant data. The use of aggregate data for the sawnwood product could possibly cause problems to the product homogeneity assumption, but as the proportions are expected to be similar for the competing countries, this should not have an effect on the final results. Hänninen (1998b p. 34) also expresses that the homogeneity assumption is well justified at least for Finland, Sweden and Russia as they have a relatively similar raw material basis and end-use sectors. The use of a production price index as a proxy for the cost of domestic sawnwood industry may cause some uncertainty in the estimation of ERPT as well. Hänninen et al. (2000) reckon that production prices are not a very good cost measure as they strongly correlate with output prices, thus suggesting that wood raw material could possibly be a better indicator. However, the lack of relevant data for Swedish sawnwood industry prevented using this approach in the present study.

4.4.1 Empirical models

As already brought forward, the effects of joining the European Monetary Union will be studied by comparing price developments of Finnish and Swedish sawnwood imports in UK and Germany to the developments of the corresponding country's exchange rate. In practice, this means studying the rate of exchange rate pass-through for both exporting countries in both destinations. This will reveal information from the effects of EMU participation to sawnwood exports within and outside the EMU region. As exchange rate effects have vanished in trade between two EMU countries the model for Finnish sawnwood exports to Germany will only comprise the export demand relation (3.3). The remaining three model systems will be estimated applying the multiequation Johansen method. These will measure the total pass-through i.e. the entire effect an exchange rate change causes, working through every interaction of the price determination. For comparison, partial pass-through will also be estimated by measuring the effect an exchange rate change has on the price setting relation alone, excluding the effects going through other variables and other long-run relations. (Adolfson 2001) Hence, seven models will be estimated separately in all. The final estimated equation systems/models will be as follows:

<u>Exports from Finland to the UK</u>

$$x_{FU} = -\eta\,(p_{FU} - p_{CU} - er_{FU}) + x_{CU} + a_0 + \varepsilon \qquad (4.26)$$

$$p_{FU} = \delta + (1 - \gamma)\,(er_{FU} + p_{CU}) + \gamma c_F + u \qquad (4.27)$$

<u>Exports from Finland to Germany</u>

$$x_{FG} = -\eta\,(p_{FG} - p_{CG} - er_{FG}) + x_{CG} + a_0 + \varepsilon, \qquad (4.28)$$

Price relation not specified for estimation

where x_{FU} and x_{FG} are the respective Finnish export quantities (m^3) to the UK and German markets, p_{FU} and p_{FG} nominal home currency unit prices (EUR/m^3) to the destination markets, x_{CU} and x_{CG} are the respective quantities and p_{CU} and p_{CG} weighted average foreign currency prices (GBP/m^3 and EUR/m^3) of the competitors' products, er_{FU} and er_{FG} are the nominal exchange rates between the euro and pound sterling (EUR/GBP) and between two euro countries (EUR/EUR = unity), c_F is the Finnish sawnwood production cost, a_0 and δ are constant terms, and ε and u are disturbance terms catching the effects of all other factors not present in the models.

<u>Exports from Sweden to the UK</u>

$$x_{SU} = -\eta\,(p_{SU} - p_{CU} - er_{SU}) + x_{CU} + a_0 + \varepsilon \qquad (4.29)$$

$$p_{SU} = \delta + (1 - \gamma)\,(er_{SU} + p_{CU}) + \gamma c_S + u \qquad (4.30)$$

<u>Exports from Sweden to Germany</u>

$$x_{SG} = -\eta\,(p_{SG} - p_{CG} - er_{SG}) + x_{CG} + a_0 + \varepsilon \qquad (4.31)$$

$$p_{SG} = \delta + (1 - \gamma)\,(er_{SG} + p_{CG}) + \gamma c_S + u, \qquad (4.32)$$

where x_{SU} (x_{SG}) and p_{SU} (p_{SG}) are the Swedish export quantity and nominal home currency unit price, SEK/m^3, to the UK (German) market, x_{CU} (x_{CG}) and p_{CU} (p_{CG}) are the respective quantity and weighted average foreign currency price, GBP/m^3 (EUR/m^3), of the competitors' products, er_{SU} (er_{SG}) is the nominal exchange rate between the krone and pound sterling (euro), SEK/GBP (SEK/EUR), and c_S

represents the Swedish production cost of sawnwood. Constants and error terms are the same as above.

It has already been shown how the magnitude of exchange rate pass-through will be derived from the models above. Before formal estimation it is however meaningful to plot some of the empirical variables in graphs and visually inspect their corresponding development to get a general view of the expected results. After estimation, these graphs can be used for further examination of the obtained estimation results. Especially, comparisons with the fluctuations of exchange rates will give the final interpretation for the estimated exchange rate pass-through coefficients. The graphs for each of the bilateral tradings can be found from appendix (1-4). These will be analyzed next.

4.4.2 Visual inspection of the data

During the period under study, both the euro and the Swedish krone have developed in the same direction against the pound sterling (Figures 1C and 2C). Thus, although the possibility of realigning the krone has remained as an option for Sweden, specific decisions have not been undergone for the period under consideration. In all, three to four sub periods can be identified in the exchange rate developments. First there was a period of approximately 30 per cent depreciation of both currencies between the years 1996 and 2000/2001. At the same time the relative Finnish foreign currency price of sawnwood decreased against the Swedish price (Figures 1D and 2D), and the Finnish exports and market share increased substantially (Figures 1B and 1F). Although exports from Sweden also increased slightly (Figure 2B), the impact was proportionally small as the overall sawnwood imports to UK increased heavily at the same time, thus decreasing Swedish market share (Figure 2F). After a period of depreciation both the euro and the krone appreciated against the pound until 2003. The Finnish relative export price increased against competitors' prices, decreasing exports and market share accordingly. From the end of 2003, both currencies remained fairly steady until 2007. Although the relative prices in pounds remained stable, Finnish exports and market share continued to decrease while Swedish sawnwood exporters were increasing market share. As suggested, this could have been, at least partially, a conscious decision of Finnish exporters to direct to more attractive markets (e.g. Japan). From 2007 the pound sterling started to depreciate against both currencies and the same development has continued till the end of the observation period for the euro. Only for the last year, the krone has depreciated again and this reverse development of the currencies can be seen as a rapid decline (rise) in the Swedish (Finnish) relative export price.

Comparing the above reported developments of the exchange rates and relative foreign currency prices to the graphs representing prices in home currency and production costs, one can make interpretations of the exporting firms' pricing strategies when the exchange rate has changed. Figures 1A and 1E show how the Finnish home currency price has developed closely with the production costs affecting the mark-up to remain relatively stationary for the whole period. This implies that exchange rate fluctuations have no had much of an impact on the mark-up. An exception is the end of year 2000, when the Finnish sawnwood FIM price had a big drop while the production costs remained more stable. This affected the mark-up to drop accordingly. The same development can be seen to have happened for the Swedish exporters (Figures 2A and 2E). All in all, the Swedish home currency price and production costs however seem not to have developed in the same close manner as in Finland. This would imply that exchange rate changes have had a stronger impact on the home currency price affecting the mark-up to vary more. This is especially true for the period of devaluation where the krone price increased while costs remained fairly stable, increasing the mark-up as well. For the period of appreciation the mark-up has on the other hand been decreasing. However, the interpretation is somewhat more difficult in this case as the costs have been rising rapidly at the same time hence affecting the home currency price to rise as well.

The setting in the German sawnwood import market is slightly different compared to the UK market because exchange rate effects no longer exist for Finnish sawnwood exporters. As Sweden decided to stay outside the EMU, the situation has naturally remained constant there. Therefore, the impact of Finnish EMU participation in the German sawnwood market will be more or less limited to studying the effects of the exchange rate development of Swedish krone against the euro and the effects this has on to relative prices i.e. the pricing strategy of Swedish exporting firms when the exchange rate changes.

The development of the Swedish krone against the euro can be divided into three to four sub periods (Figure 4C). Between 1995 and 1997 the Swedish krone appreciated against the euro by about 23 per cent. This was followed by a period of 20 per cent depreciation until the end of 2001, from where on the krone remained quite steady or slightly depreciated until 2007. In 2008 the krone had a remarkable slump, depreciating almost 10 per cent in just a few months. The same periods can be roughly distinguished in the development of relative foreign currency prices and market shares (Figures 3D, 3F, 4D and 4F); the period of appreciation has slightly raised the Swedish relative export price affecting the exports and market share to decline and the period of depreciation can be seen as a moderate decline of the relative price and an increase of export quantities and market share. A somewhat surprising exception to this has been the late 2008, when the Swedish export price rose against the Finnish price at the same time as the krone depreciated heavily against the euro.

As in the UK market, the Swedish mark-up has moved in parallel with the exchange rate fluctuation. In the beginning of the period, the appreciation of the krone pushed the home currency price downwards, which in turn caused the mark-up to decrease as the production costs remained in level (Figures 4A and 4E). In contrast, the depreciation period until 2002 can be seen as a rapid rise of the mark-up. The impact of the krone for the end of the observation period where costs have been rising is, again, more problematic to interpret. The mark-up has actually been decreasing although the krone has been weakening. This is just the opposite development than what has been experienced in the past. An explanation for this could be that the declining demand in the German market could have brought about a switch in Swedish exporters' pricing strategy. The Finnish mark-up has been rather stationary for the whole observation period implying that the home currency price is set by how the costs have and are expected to develop (Figures 3A and 3E). This is not surprising, as exchange rate effects have disappeared from intra-EMU trade.

According to the graphical inspection it seems that exchange rate changes have affected Finnish sawnwood exporters' competitiveness and market share in the UK market. Devaluations have been used to improve price competitiveness and gain market share, while profits (mark-up) have been kept more stationary. The impact of currency appreciation has been the opposite. These findings are consistent with earlier studies of the effects of exchange rate changes on Finnish sawnwood exports and prices (Hänninen 1998a). The pricing strategy of Swedish sawnwood exporters is interesting, as it seems to be the exact opposite of what Finnish sawnwood industry firms have been using in the past. The krone price of Swedish sawnwood and hence mark-up has varied more with the exchange rate, implying that a larger proportion of the currency change is used for profit purposes. When the krone has depreciated (appreciated), the home currency price and the mark-up have increased (and vice versa) making the exporting firms more (less) profitable. At the same time, the foreign currency price has remained more stable implying that in case of krone depreciation, exporting firms have not lowered prices to increase market share. An important implication of this would be that joining the EMU might have not affected Finnish exporters' price competitiveness, in the sense that krone depreciations have been rather used for profit purposes. In the long-run, Swedish producers' profit increases would, however, indirectly influence the competitiveness of Finnish sawnwood producers.

5. ESTIMATION RESULTS

The preliminary conclusions made above were based purely on visual inspection of the data. However, explicit tests, taking into account time series properties of the data, are required to obtain statistically accurate information. This section will present the results obtained from the formal estimation of the models shown in the previous chapter. Vector autoregressive (VAR) representations for each of the country pairings will provide the initial statistical representations of the data. The following will then test the inference of cointegration, weak exogeneity and long-run relationships between variables in the conditional VAR representations using the multivariate approach of Johansen (1991). Finally, complete structural econometric models will be developed from where the elasticity estimates can be obtained.

5.1 The UK sawnwood market

5.1.1 Unrestricted VAR and cointegration

The empirical analysis starts with an unrestricted VAR representation as shown by equation (5.17) for the period 1995-2008. The systems were derived separately for both Finnish and Swedish exports to the UK as explained in the previous chapter. In the present context, there were added *a priori* modifications to the generalized models for including impulse dummy variables, D_t, to take account for unexplained price movements. These were included as exogenous variables in the model, so that the final estimated model systems each consist of six equations (p = 6).

The lag length, k, was determined by using the Schwarz (SC) and Hannan-Quinn (HQ) information criteria. With a maximum number of five lags, the information criteria point towards low values of the lag length: k = 1 by both criteria in each system (Table 5.1). Considering the dimension of the system and the fairly low number of observations this seems feasible. The sequentially modified likelihood ratio (LR) test statistic also indicated one lag as optimal for the system of Finland, whereas a reduction of the VAR from k = 4 to k = 3 was rejected for the system of Sweden. At this point, the cointegration analysis was proceeded with the conclusion that the relevant lag length to be used is one in both systems. The appropriateness of the chosen lag lengths were further on supported by the rejection of null hypothesis of residual autocorrelation on the residuals of both models. A more thorough testing of the residuals will be conducted after formulation of the unrestricted VARs.

Table 5.1 Lag order determination of unrestricted VAR models for the UK market under $p = 6$. Estimation samples 1995:1-2008:4.

	Finland - UK			Sweden - UK		
Lag (*k*)	**LR**	**SC**	**HQ**	**LR**	**SC**	**HQ**
0	NA	-11.57	-11.85	NA	-13.46	-13.74
1	352.45*	-16.99*	-18.11*	211.11	-15.59*	-16.71*
2	43.04	-15.37	-17.34	71.40	-14.74	-16.71
3	47.10	-14.12	-16.93	46.52	-13.47	-16.28
4	39.15	-12.91	-16.56	52.84*	-12.81	-16.46
5	39.46	-12.21	-16.70	36.08	-11.93	-16.43

Notes: 1) * indicates lag order selected by the criterion at 5% level.
2) LR = sequential modified LR test statistic, SC = Schwarz information criterion, HQ = Hannan-Quinn information criterion

The next step in the estimation procedure is to determine the cointegration rank, r, for each of the systems and derivation of an $I(0)$ representation. Although the Johansen methodology is usually used in a setting where all the variables are ordered of degree one, having stationary variables is theoretically not conceived problematic: a single $I(0)$ variable will reveal itself through a cointegrating vector whose space is spanned by the only stationary variable in the model. Hjalmarsson and Österholm (2007) however note that this apparent flexibility of not needing to test the stationarity of variables does not make the method robust to near-integrated variables, since they fall into neither stationary or non-stationary classifications. Rahbek and Mosconi (1998) have also addressed the issue of including stationary variables in a VAR model, and stated that these will lead to nuisance parameters in the asymptotic distribution of the trace statistic for cointegration rank. However, as stated that a trend-stationary process can well approximate a unit root process, it is thus presumed to have a long memory so that an ECM representation is applicable.

The ADF unit root tests indicated that the data of the two models are of $I(1)$ or $I(0)$, implying that the Johansen methodology is applicable (Table 5.2). Yet, stationary variables can have an effect on the number of cointegrating relationships found by the Johansen cointegration test. Therefore, according to the unit root test results $r \geq 2$ could be found in the system for Finland if a model comprising a constant and a trend is used: in addition to the apparently trend-stationary variables, from the theoretical point of view, two cointegrating vectors (demand and price) should be found. The system for Sweden does not have stationary variables in levels outside the already assumed cointegrating vectors, so that $r = 2$ should be found according to the theory.

Table 5.2 Augmented Dickey-Fuller (ADF) unit root test results for the UK market data. Estimation samples 1995:1–2008:4.

Variables	Level (C)		First difference (C)		Level (CT)		First difference (CT)	
Finland - UK								
x_{FU}	-1.42		-7.46	**	0.30		-8.03	**
p_{FU}	-3.22	*	-9.58	**	-3.18		-9.50	**
er_{FU}	-1.86		-4.93	*	-0.08		-5.95	**
c_F	-2.41		-4.32	**	-3.56	*	-4.34	**
p_{CU}	-2.44		-7.94	**	-2.4		-7.82	**
x_{CU}	-1.70		-9.87	**	0.43		-10.85	**
Sweden - UK								
Variables	**Level (C)**		**First difference (C)**		**Level (CT)**		**First difference (CT)**	
x_{SU}	-2.15		-8.61	**	-1.36		-8.94	**
p_{SU}	-3.84	**	-10.75	**	-4.65	**	-10.62	**
er_{SU}	-2.01		-5.11	**	-0.83		-5.24	**
c_S	-1.70		-5.42	**	-2.08		-5.35	**
p_{CU}	-2.27		-4.12	**	-2.10		-4.09	*
x_{CU}	-1.67		-7.79	**	0.40		-8.78	**

Notes: 1) Critical values by Dickey and Fuller (1979).
2) Tested using Schwarz info criterion with max 5 lags and a constant (C) and a constant plus a trend (CT).
3) *(**) denotes rejection of the null hypothesis of nonstationarity at 5% (1%) level.

In addition to stationary variables, Johansen (1994) has shown how deterministic terms such as the intercept, linear trend, and indicator variables influence both data behavior and limiting distributions of estimators and tests in integrated processes. Also Doornik et al. (1998) stress that appropriate formulation of the model is important to ensure the cointegration rank tests are not too dependent on the nuisance parameters related to the deterministic components. Following the suggestion of Johansen (1992a), the Pantula principle, in which starting from the most restricted model and proceeding step by step to a more unrestricted model, was adopted in the selection of the appropriate model as well as in the determination of the cointegration rank. Also a simple inspection of the data series was inducted. Indications of quadratic trends in either system were not found. Only linear trends can be thought to be present in X_t so that two models remain for analysis: a model allowing for a trend in X_t, while the cointegrating relations $\beta' X_t$ are stationary and a model which allows for deterministic trends both in X_t and the cointegrating relations. The former means adding a constant (C) in the model and the latter adds a constant and a trend (CT).

Results regarding the cointegration estimation of the VAR(1) models indicate that there may be more than two cointegrating vectors, $r \geq 2$, in the model for Finland at the 5 per cent level (Table 5.3 and Appendix 5A). Moreover, the trace test and the maximum eigenvalue test give somewhat conflicting results for the data of the Finnish model. This may be due to fairly small sample sizes used in the study and therefore low power of the distinctive tests. Kongsted (1998) also emphasizes that the asymptotic distributions of the test statistics are only approximations, as they do not allow for the inclusion of exogenous D_t terms in (5.17). This may also be reflected in the contradictory test results.

Table 5.3 Tests of cointegration rank of unrestricted VAR models for the UK market. Estimation samples 1995:1–2008:4.

	Finland - UK		Sweden - UK	
Data trend	Linear	Linear	Linear	Linear
Deterministic terms	Intercept (C) No Trend	Intercept (C) Trend (T)	Intercept (C) No Trend	Intercept (C) Trend (T)
Trace test	3	3	2	2
Max-Eigen test	1	2	2	2

Note: Critical values based on MacKinnon-Haug-Michelis (1999).

As mentioned, in the present study $r = 2$ would be consistent with the theoretical presumption, that the export demand and domestic price relations are formed simultaneously and equilibrate in the long-run. However, as the cointegration rank is affected by stationary variables and by included deterministic terms, also cases where $r > 2$ were investigated as indicated by the cointegration test results. The inclusion of deterministic components was based on the Pantula principle and the significance of the added drift term as well as on inspection of the stationarity of the cointegrating relations. According to the results, the data for Finland is trend-stationary: the drift term eliminates trends from the cointegration relations and, in addition, the trend term is highly significant in the vector relations, increasing the likelihood of the whole system. Using the Pantula principle, neither of the model specifications could be rejected for $r \leq 2$ by the trace test. Following Enders (2004, p. 354), the maximum eigenvalue test was finally chosen to be used to reduce the number of cointegration relations. Therefore, as a model comprising an intercept and a trend term was used for further modelling, two cointegrating vectors ($r = 2$) can not be rejected in the system at the 5 per cent level. On the other hand, the data for Sweden did not show any signs of trend-stationarity and according to the Pantula principle $r \leq 2$ could not be rejected for the first time when including only an intercept in the model specification. The presumption of two cointegrating vectors ($r = 2$) can thus not be rejected for the Swedish model as well. The resulting normalized Maximum Likelihood Estimates (MLE), β_j, and their corresponding weights, α_j, obtained from the cointegration estimations are shown in table (5.4).

Table 5.4 Normalized MLEs of vectors β_j and loadings α_j in models for the UK market. Estimation samples 1995:1–2008:4.

Finland - UK			Sweden - UK		
	Vectors			Vectors	
Variables	β_1	β_2	Variables	β_1	β_2
x_{FU}	1.00	-0.08	x_{SU}	1.00	4.39
p_{FU}	-0.19	1.00	p_{SU}	0.22	1.00
er_{FU}	-1.04	-0.41	er_{SU}	-0.19	-0.47
c_F	-1.06	0.67	c_S	-0.17	-1.38
p_{CU}	-0.15	-1.08	p_{CU}	-0.19	-0.43
x_{CU}	-1.74	0.08	x_{CU}	-0.47	-2.17
	Weights			Weights	
Variables	α_1	α_2	Variables	α_1	α_2
x_{FU}	0.36	1.47	x_{SU}	-18.07	3.96
p_{FU}	-0.25	-1.24	p_{SU}	2.49	-0.45
er_{FU}	-0.01	-0.15	er_{SU}	-0.86	0.20
c_F	0.00	-0.03	c_S	-1.93	0.47
p_{CU}	0.24	0.60	p_{CU}	5.54	-1.22
x_{CU}	0.67	0.57	x_{CU}	-23.89	5.47

Note: Estimates of β_j normalized on export quantity and domestic price.

Of the six eigenvectors in both systems, the first two relations were found to be most highly correlated with the stationary part of the process Δx_t and were thus normalized on export demand, x_i, and home currency price, p_i, These are to be further over-identified by imposing restrictions driven from the underlying economic theory. The α_{ij}'s represent the weights with which the error correction terms enter each equation, indicating the speed of adjustment toward the estimated equilibrium state. Fairly low values in the system for Finland imply low adjustment, whereas larger values in the system for Sweden imply a rapid adjustment process. In the system for Sweden, loadings on the variables representing quantities (x_{SU} and x_{CU}) raise some concern, but were at this point maintained without further examination.

Overall, graphs of the cointegration relations seem to be fairly stationary (Appendix 5B), stating that the VARs have been reduced to $I(0)$ space and thus the assumptions maintained regarding the error term, ε_t, could be examined by various diagnostic tests on the equation systems. The results are reported in table (5.5). As suggested by Doornik (1995), the F-form of the Lagrange Multiplier (LM) test was used to examine serial correlation on the residuals. The main advantage of the LM test compared to other autocorrelation tests is that it is valid for systems with lagged dependent variables and it performs well in smaller samples as well. Heteroskedasticity was tested using the White (1980) heteroskedasticity test without cross terms primarily because it does not require explicit formulation of the form of the heteroskedasticity. Finally, normality of the residuals was tested by means of Jarque-Bera normality tests (1980) via Cholesky (JB_{CHOL}) and Urzua (JB_{URZ}) factorizations. All of the tests are readily available in EViews 6. The null hypotheses of no autocorrelation and homoskedasticity could not be rejected at the 5 per cent level for each of the equation systems. Also both normality tests based on the Jarque-Bera statistic did not reject the null hypothesis of multivariate normality. As no misspecification test was significant at the conventional 5 per cent level, there is strong evidence that the systems represent adequately the data. Moreover, the estimation procedure could be continued without modifications to the original models.

Table 5.5 Misspecification tests on model systems for the UK market under $r = 2$. Estimation samples 1995:1–2008:4.

	Autocorrelation (LM)	**Heteroskedasticity** (White)	**Normality** (JB_{CHOL})	(JB_{URZ})
		Finland - UK		
Statistic	34.74*	359.64*	14.17*	112.60*
Prob.	0.52	0.45	0.28	1.00
		Sweden- UK		
Statistic	45.70*	378.96*	19.22*	126.52*
Prob.	0.12	0.20	0.08	0.99

Note: * denotes significance at 5% level.

5.1.2 Estimation of total exchange rate pass-through

The next step is to examine the obtained unrestricted cointegration vectors with restrictions imposed from economic theory. This is done in order to identify the systems comprising export demand and price relations for Finnish and Swedish sawnwood in the UK market. First, the validity of conditioning the analysis of the long-run relationships on these relations will be considered. Then, the long-run structure of the cointegrating relations will be formulated.

Valid conditioning requires that a variable is weakly exogenous for the long-run parameter, β (Kongsted 1998). As was shown by equation (*5.25*), this requires restrictions on the loadings, α, by setting the appropriate rows of the matrix with zeros ($\alpha_{ij} = 0$). This implies that the variable does not adjust to deviations from the long-run steady state relations as defined by the cointegrating relations. *A priori*, from an economic point of view it is expected, on the one hand, that at least the prices of exports and export quantities adjust. This is the basic assumption of the theory of demand and supply equilibrium. On the other hand, exchange rates are not expected to respond to changes in export quantities and domestic prices, as exporters are not expected to be able to affect exchange rates with their own strategies. The same assumptions can be made by looking at the values of the loadings in table (5.4). A large value indicates that the variable adjusts towards the long-run equilibrium, whereas low values imply lower correlation with the steady state. The LR tests of weak exogeneity of each variable for β are reported in appendix (5C). The null of weak exogeneity is rejected at the 5 per cent level in both systems for all variables except for exchange rates, i.e. the feedback is weak to this domestic variable. The implication is that for Finland the exchange rate is given by the monetary policy of the ECB. For Sweden, the Riksbank is operating independently as well, so that exchange rates are not affected by the decisions of Swedish sawnwood exporters. These results were as expected and therefore no further examination is needed.

The next step was to identify the model systems by restricting the long-run coefficients accordingly. From the unrestricted cointegration vectors, the first relation in both systems was identified as the demand equation (3.3), by excluding production costs, c_i, from the relation ($\beta_{41} = 0$) and by setting the coefficients of competing exports, x_o, to -1 ($\beta_{61} = -1$). The latter restriction was however relaxed from both of the models, as the coefficients for competing exports (x_o) in the unrestricted models deviated fairly much from the proposed value. The implication is that competing sawnwood exports do not change one-for-one with domestic exports and therefore the constant market share (CMS) assumption does not hold. This was already noticed from a simple inspection of the annual data presented in Chapter 2, which showed even somewhat opposite fluctuations in imported quantities among the main competitors. The second cointegrating vector, β_2, in both systems was identified as the price equation (4.9) by excluding the variables representing export quantities, x_i and x_o, from the relation ($\beta_{12} = 0$ and $\beta_{62} = 0$).

The maximum likelihood estimates of a hierarchy of long-run structures (I - II) formulated as (5.24) are reported in Table (5.6). As already pointed out in the economic framework of the study, the theoretical model suggests long-run relations for both export quantity and price to be homogenous in the nominal variables. These homogeneity restrictions are presented as the first testable long-run structure (I). According to the equations (3.3 and 3.9) this means that the coefficients of p_o and er_i should be equal in both relations ($\beta_{5j} = \beta_{3j}$) and the coefficient of c_i should equal the difference between the coefficients of p_i and er_i in the price vector ($\beta_{42} = -(\beta_{22} + \beta_{32})$). (Hänninen 1998a) The former restriction implies that relative prices determine export demand and the latter restriction that a marginal cost change and an exchange rate change have identical effects on the price measured in the local currency (Adolfson 2001)

The results show that the long-run homogeneity restriction was not rejected in the model system for Finland, but rejected in the system for Sweden. This latter result is rather peculiar, as the coefficients in the unrestricted model for Sweden indicate only minimal deviation from the homogeneity assumption. Athukorala and Menon (1995) have however noted that in practice it is common that these coefficient restrictions are not valid. They point out that exchange rates tend to be more volatile than both world price and production costs and therefore firms may be more willing to absorb changes in exchange rates into their profit margins. Moreover, even if the competition is limited, firms may still wish to stabilize local currency prices given shocks to exchange rates. Also Bache (2002) argues that exchange rate changes are often seen as temporary and therefore exporters will be willing to absorb them in their mark-ups.

Table 5.6 LR tests of structural hypotheses on model systems for the UK market under $r = 2$. Estimation samples 1995:1–2008:4.

Finland - UK				
Variables/ LR-test	(I) Long-run homogeneity		(II) Mark-up pricing	
	β_{i1}	β_{i2}	β_{i1}	β_{i2}
x_{FU}	1.00	0.00	1.00	0.00
p_{FU}	2.38	1.00	2.14	1.00
er_{FU}	-2.38	-0.32	-2.14	0.00
c_F	0.00	-0.68	0.00	-1.00
p_{CU}	-2.38	-0.32	-2.14	0.00
x_{CU}	-1.51	0.00	-1.51	0.00
LR	χ^2 = 13.13		χ^2 = 13.71	
Prob.	0.07		0.09	

Sweden - UK				
Variables/ LR-test	(I) Long-run homogeneity		(II) Mark-up pricing	
	β_{i1}	β_{i2}	β_{i1}	β_{i2}
x_{SU}	1.00	0.00	1.00	0.00
p_{SU}	0.93	1.00	0.23	1.00
er_{SU}	-0.93	-0.82	-0.23	-1.00
c_S	0.00	-0.18	0.00	0.00
p_{CU}	-0.93	-0.82	-0.23	-1.00
x_{CU}	-0.46	0.00	-0.48	0.00
LR	χ^2 = 22.85*		χ^2 = 23.24*	
Prob.	0.00		0.00	

Notes: 1) * denotes rejection of the restricted model system at 5% level.
2) β_{i1} and β_{i2} correspond to export demand and price relations respectively.

Although the long-run homogeneity structure could be rejected on the model for Sweden, the restrictions on the model for Finland could not be and the results are in accordance with earlier findings regarding ERPT estimates for Finnish sawnwood exports (e.g. Hänninen 1998a). The coefficient of production costs, c_F, is much closer to unity than zero (-0.68), meaning that the price relation resembles a mark-up pricing relation for which $\gamma = 1$ = ERPT. Also the relatively large exchange rate elasticity of export demand (2.38) implies a large effect of exchange rate on Finnish sawnwood exports to the UK. The mark-up assumption (II) was tested by restricting the price relation accordingly (β_{42} = -1). The probability of this model structure decreased slightly, so that the equation system could not be rejected now by a larger margin. The mark-up pricing structure was tested on the system for Sweden by restricting the pass-through coefficient to zero (β_{42} = 0), as the coefficient of c_S was not even to unity (-0.18). Also, fairly low magnitude of the exchange rate elasticity (0.93) implies lower effect of the krone value on Swedish sawnwood exports to the UK than for the euro value on Finnish sawnwood exports. The likelihood in this model lowered slightly, thus still indicating a clear rejection of the overall model structure. The result would further state that, although Swedish exports of sawnwood to the UK have been less sensitive to exchange rate changes than Finnish sawnwood exports, the effect on prices and exported quantities cannot be completely rejected.

5.1.3 Estimation of partial exchange rate pass-through

Because the equation system for Sweden failed both of the structural tests, interpretation of its coefficients is problematic. Moreover, making of further conclusions of the pricing strategy of Swedish sawnwood exporters is difficult and rather unreliable. Exceptionally high values of some of the loadings in the system for Sweden imply that the overall fit of the model is weak. As the Johansen procedure does not perform well in small samples, these problems could be arisen also from using a heavy system with fairly many variables proportionate to the number of total observations. Therefore, to further examine the validity of the obtained ERPT estimates, a simpler model comprising only the price relation was tested. The same kind of model has been applied for example by Hänninen and Toppinen (1999) for testing exchange rate effects on Finnish pulp and paper exports to Germany and the UK.

The procedure is the same as with the original model systems, the only difference being that now, provided that the data series support the underlying theory, only the price relation is assumed to cointegrate as the variables representing quantities are excluded from the model ($p = 4$). The proposed optimal lag lengths by the different information criteria were conflicting: the Schwarz information criteria suggesting $k = 1$ for both models and Hannan-Quinn information criteria $k = 2$ and $k = 3$ for the respective models of Finland and Sweden (Appendix 5D). However, as the diagnostic tests detected autocorrelation up till two lags in the model for Finland, three lags ($k = 3$) was chosen to be used for further modelling. Also the Likelihood ratio test and Akaike (AIC) information criterion indicated three lags as optimal. In the model for Sweden, additional lags did not eliminate autocorrelation, so that one lag ($k = 1$) was retained as in the original model system.

The deterministic components were kept as in the derived model systems before, so that the model for Finland comprises both a linear trend and an intercept, and the model for Sweden only an intercept. The significance of the added drift term was used as the determinant factor. The cointegration rank test result of the VAR(3) model for Finland indicated one cointegrating vector, $r = 1$, by the trace test at the 5 per cent significance level (Appendix 5E). This was identified as the price vector as demonstrated earlier. In the VAR(1) model for Sweden the trace test statistic for $r \leq$

2 is above the critical value at the 5 per cent level, meaning that r = 1 could not be readily attained. However, as demonstrated in several studies (e.g. Ahn and Reinsel 1990, Reimers 1992 and Johansen 2002) by making a small sample correction, often based on the degrees of freedom, the LR test statistic will decrease which in effect could diminish the number of cointegration relations found by the Johansen test. In the present case this would imply that a single cointegrating vector could be obtained. However, as the procedure is rather complicated, it was not conducted explicitly in the present case. The estimation was instead proceeded with the assumption of r = 1 for the model for Sweden. Stationarity of the cointegration relations, normalized on domestic price, support the resulting VAR model structures as well as misspecification tests on the residuals of the model for Finland (Appendix 5F and 5G). However, tests of autocorrelation and heteroskedasticity reject the model structure for Sweden, causing possible bias to the results. The maximum likelihood estimates of the restricted structures (I-II) are presented in table (5.7).

Table 5.7 LR tests of structural hypotheses on models for the UK market under r = 1. Estimation samples 1995:1–2008:4.

Finland - UK		
Variables/ LR-test	(I) **Long-run homogeneity**	(II) **Mark-up pricing**
	β_{i1}	β_{i1}
p_{FU}	1.00	1.00
er_{FU}	-0.39	0.00
c_F	-0.61	-1.00
p_{CU}	-0.39	0.00
LR	χ^2 = 3.33	χ^2 = 3.91
Prob.	0.34	0.42

Sweden - UK		
Variables/ LR-test	(I) **Long-run homogeneity**	(II) **Mark-up pricing**
	β_{i1}	β_{i1}
p_{SU}	1.00	1.00
er_{SU}	-0.74	-1.00
c_S	-0.26	0.00
p_{CU}	-0.74	-1.00
LR	χ^2 = 4.69	χ^2 = 5.20
Prob.	0.19	0.27

Notes: 1) * denotes rejection of the restricted model system at 5% level.
2) β_{i1} corresponds to the price relation.

The results indicate acceptance of the homogeneity restriction (I) for both models at the conventional 5 per cent level. Furthermore, the estimation results of the single equation models resemble the results obtained from the multi-equation models: coefficients for long-run exchange rate pass-through of 0.61 and 0.26 are obtained on to the sawnwood price of Finland and Sweden respectively. Hence, the Finnish price relation again suggests more of a mark-up pricing strategy whereas for Swedish exporters exchange rate changes have seemingly had a much larger effect on price determination in domestic currency. Consequently, the mark-up restriction (II) increased the probability of the whole model structure for Finland and could thus not be rejected. Again, according to the obtained unrestricted pass-through coefficient, the mark-up structure (II) for Sweden was tested with a zero pass-through model structure. The probability of the price relation increased considerably along with the mark-up restriction, indicating a non-rejection of this particular pricing behavior. Moreover, as the homogeneity restriction itself is now plausible for both models, the interpretation of the coefficients is meaningful. Yet some caution has to be advised not to over interpret the results of the model for Sweden, as the VAR structure did not pass some of the diagnostic tests on residuals.

5.2 The German sawnwood market

The estimation of the models for the German sawnwood market follows the same procedure as demonstrated above. Yet, after elimination of the exchange rate effect in intra-EMU trade for Finland, only the export demand relation will be assumed to cointegrate in the long-run. The presumed multi-equation method is thus not valid anymore and the estimation will follow a more conventional single-equation method, although in a multivariate context. Nevertheless, the Johansen method is applied so as to add appropriate restrictions in deriving the final model structure. The approach in deriving the long-run ERPT estimate for Sweden is the same as applied for the UK market. However, as the data did not support a multi-equation system and the obtained coefficients were not meaningful, only results regarding the derivation of a price relation will be presented in the study.

5.2.1 Unrestricted VAR and cointegration

The first step was to derive the unrestricted VAR representations for both models separately for the period 1995-2008. As previously suggested, there seems to be a change in pricing strategy for Swedish sawnwood exporters to Germany from the beginning of 2006 onwards. After preliminary testing of the data, the estimation period in the model for Sweden was consequently chosen to be modified, so that the final estimated model would comprise data only until the second quarter of 2006. Impulse dummy variables, D_t, were again included into both of the generalized models to take account for observable outliers in the data. The dummy terms were included as exogenous variables so that the final estimated models for Finland and Sweden comprise each four equations.

The lag length, k, was determined by the Schwarz (SC) and Hannan-Quinn (HQ) information criteria, subject to Gaussian residuals, using a maximum of five lags. The results are convergent between the criteria in the model for Sweden but contradictory for the data of Finland as can be seen from table (5.8). Both information criteria indicated two lags to be suitable for the Swedish data and as the misspecification tests revealed no signs of autocorrelation, a VAR(2) model was chosen to be used for Sweden. Moreover, the sequentially modified likelihood ratio test as well as the Akaike (AIC) information criterion indicated two lags to be optimal for the data of Sweden. For the model of Finland, the Schwarz (SC) information criterion indicated on lag to be optimal while the LR test and Hannan-Quinn information criterion suggested four lags to be optimal. However, as simple diagnostic tests revealed signs of autocorrelation on the residuals of the model for Finland using two and four lags, a VAR(3) representation was chosen to be used.

Table 5.8 Lag order determination of unrestricted VAR models for the German market under $p = 4$. Estimation samples 1995:1–2008:4/2006:2.

	Finland - Germany			Sweden - Germany		
Lag (k)	LR	SC	HQ	LR	SC	HQ
0	NA	-5.89	-6.07	NA	-14.59	-14.81
1	140.98	-7.79*	-8.35	91.97	-15.77	-16.41
2	29.99	-7.29	-8.22	50.85*	-15.96*	-17.03*
3	35.66	-7.02	-8.33	5.90	-14.73	-16.22
4	32.80*	-6.78	-8.46*	15.35	-13.95	-15.87
5	16.83	-6.12	-8.18	15.11	-13.30	-15.64

Notes: 1) * indicates lag order selected by the criterion at 5 % level.
2) LR = sequential modified LR test statistic, SC = Schwarz information criterion, HQ = Hannan-Quinn information criterion

Before testing the cointegration rank of the separate models, stationarity of the variables and the inclusion of possible deterministic components were examined. The ADF unit root test results shown in table (5.9) indicate that none of the series is integrated of higher order than one, $I(1)$, so that the Johansen cointegration method can be applied in its basic form. However, depending on the deterministic components included in the models, stationarity of some of the variables could have an effect on the cointegration rank test results. In the present context it is again assumed, and supported by visual inspection of the data series, that the apparently stationary variables are in fact trend-stationary and thus likely long-memoried. Therefore, an error-correction form is suitable for the representation of the data even in the presence of stationary variables.

Table 5.9 Augmented Dickey-Fuller (ADF) unit root test results for the German market data. Estimation samples 1995:1–2008:4/2006:2.

Finland - Germany								
Variables	Level (C)		First difference (C)		Level (CT)		First difference (CT)	
x_{FG}	0.05		-7.37	**	-5.54	**	-7.40	**
p_{FG}	-3.05	*	-7.54	**	-3.65	*	-7.48	**
p_{CG}	-2.66		-7.59	**	-2.79		-7.59	**
x_{CG}	-2.03		-2.98	*	-3.84		-3.12	
Sweden - Germany								
Variables	Level (C)		First difference (C)		Level (CT)		First difference (CT)	
p_{SG}	-2.84		-5.13	**	-3.85	*	-5.11	**
er_{SG}	-1.48		-4.60	**	-2.80		-4.73	**
c_S	-1.70		-5.42	**	-2.08		-5.35	**
p_{CG}	-2.44		-6.67	**	-2.74		-6.70	*

Notes: 1) Critical values by Dickey and Fuller (1979).
2) Tested using Schwarz info criterion with max 5 lags and a constant (C) and a constant plus a trend (CT).
3) *(**) denotes rejection of the null hypothesis of nonstationarity at 5% (1%) level.

A simple inspection of the data reveals that neither of the datasets incorporates quadratic trends, so that assuming a linear time trend two model specifications remain under consideration: a model comprising a constant (C) for allowing a trend in X_t and a model comprising a constant and a trend (CT) for allowing, in addition to the former, a trend in the cointegrating relation $\beta' X_t$. To avoid a decision whether the trend is just in the variables and hence orthogonal to the cointegration relations or fully general, both types of tests are performed (Lütkepohl 2004). As expressed in deriving the model systems, the so-called Pantula principle is useful in determining the final specification of the model and the corresponding cointegration rank. In the present context this was done by moving from the restricted model (constant) to the less restricted model (constant and trend) and comparing the rank test statistic in each of the specifications with the chosen quantile of the corresponding table. When the null hypothesis could not be rejected for the first time, this particular model would then be chosen. In addition, the significance of the added trend term and its balancing effects on the cointegration relation were used as indicators for the appropriate model specification.

The results of the cointegration tests are presented in appendix (6A) and summarized in table (5.10). For the VAR(3) model of Finland, the results of the distinctive tests, and even between the possible model specifications regarding deterministic terms, are highly convergent. The null hypothesis of $r \leq 1$ for the model of Finland could not be rejected at the 5 per cent level by the trace test when using the restricted model, and in the case of relaxing the restriction on the cointegrating relation $\beta'X_t$. According to the Pantula principle, the restricted model specification should be chosen. However, as the added trend term was highly significant and smoothened the cointegration relation, the latter model specification was chosen to better represent the data generating process. In the VAR(2) model for Sweden there is non-convergence between the distinctive tests, and moreover between the model specifications. The model comprising only an intercept could be rejected in the presence of one cointegrating vector ($r \leq 1$), but could not be when a trend term is added. Yet, after testing the significance of the added drift factor, the former model specification was chosen to better approximate the data generating process for data of Sweden. Using the degrees of freedom corrected version on the cointegration rank test, the number of cointegrating relations could again be pinned down, so that a single vector can be assumed to cointegrate in the long run for the model of Sweden as well. This small sample correction is well justified due to the reduction of the observation period and hence the sample size.

Table 5.10 Tests of cointegration rank of unrestricted VAR models for the German market. Estimation samples 1995:1–2008:4/2006:2.

	Finland - Germany		**Sweden - Germany**	
Data trend	Linear	Linear	Linear	Linear
Deterministic terms	Intercept (C) No Trend	Intercept (C) Trend (T)	Intercept (C) No Trend	Intercept (C) Trend (T)
Trace test	1	1	2	1
Max-Eigen test	1	1	0	0

Note: Critical values based on MacKinnon-Haug-Michelis (1999).

After specification of the unrestricted VAR models, the maximum likelihood estimates of the eigenvectors β_j, and their corresponding weights, α_j, can be obtained (Table 5.11). Of the four eigenvectors in each of the models, the first relations were found to be most highly correlated with the stationary part of the process Δx_t and could thus be normalized on export quantity x_{FG} and domestic price p_{SG} for the respective models. Overall the models seem to be well specified and the long-run coefficients have the expected signs and magnitudes. Furthermore, the loadings are fairly low for each of the models, implying slow average adjustment speed towards the equilibrium state.

Table 5.11 Normalized MLEs of vectors β_j and loadings α_j in models for the German market. Estimation samples 1995:1–2008:4/2006:2.

Finland - Germany			Sweden - Germany		
Variables	Vectors β_1	Weights α_1	Variables	Vectors β_1	Weights α_1
x_{FG}	1.00	-0.48	p_{SG}	1.00	-0.89
p_{FG}	3.77	-0.07	er_{SG}	-0.62	0.02
p_{CG}	-0.93	-0.09	c_S	-0.12	0.04
x_{CG}	-0.40	-0.54	p_{CG}	-0.70	-0.05

Note: Estimates of β_j normalized on export quantity (x_{FG}) for the model of Finland and on domestic price (p_{SG}) for the model of Sweden.

Graphical representations of the above normalized cointegration relations indicate an $I(0)$ process (Appendix 6B), so that the error terms of the unrestricted VARs could next be examined by various diagnostic tests. The results are presented in table (5.12). The null hypothesis of vector error autocorrelation was tested with the F-type Lagrange Multiplier (LM) test, and could be rejected for both models at the 5 per cent level. The null hypothesis of heteroskedasticity was tested with the F-form of White heteroskedasticity test without cross terms and could also be rejected for each of the models with the 5 per cent level. Multivariate normality was tested with two distinctive Jarque-Bera tests (JB_{CHOL} and JB_{URZ}), which both rely on the skewness and kurtosis of the residuals. The null hypothesis of multivariate normality could only be rejected when applying the Cholesky decomposition on the model for Finland. Vector error correction models are though to some extent robust for non-normality, provided that the errors are symmetrically distributed as is the case here (Johansen 1995, p. 29). Overall, the models seem to be well specified and the propositions made about the error terms are by most parts fulfilled. Yet, some caution has to be exercised in interpreting the final results for Finland as the structural tests below are derived under the assumption of Gaussian residuals (Johansen 1991).

Table 5.12 Misspecification tests on models for the German market under $r = 1$. Estimation samples 1995:1–2008:4/2006:2.

	Autocorrelation (LM)	Heteroskedasticity (White)	Normality (JB_{CHOL})	Normality (JB_{URZ})
	Finland - Germany			
Statistic	15.04*	276.05*	21.12	48.86*
Prob.	0.52	0.12	0.01	0.71
	Sweden- Germany			
Statistic	21.78*	172.19*	12.02*	64.08*
Prob.	0.15	0.44	0.15	0.19

Note: * denotes significance at 5% level.

5.2.2 Estimation of long-run relations

The main concern of the present study consists of the matrix of the long-run multipliers, $\Pi = \alpha\beta'$. In order to identify the long-run relationships among the unrestricted cointegration relations, one needs to first test certain hypotheses. These were derived from the underlying trade theory in this case. Restrictions on α, for testing of weak exogeneity and β, for identifying individual relations with an economic interpretation, will be considered next.

As demonstrated by Johansen (1992b), the analysis of the loadings α, is related to testing of weak exogeneity when the parameter of interest is the matrix of cointegrating vectors β. Again, *a priori* assumptions were made on the variables which are not expected to adjust to deviations from the steady state relation. In the model for Finland, the domestic price, competitors' prices and competitive exports are all expected to adjust to changes in domestic exports. These presumptions are based on the fact that Finland is a major player in the German sawnwood market. In the model for Sweden, competitors' prices are also assumed to adjust to changes in domestic price, while feedback of the exchange rate as well as possibly the production costs is assumed to be low. The LR test of weak exogeneity of each variable is presented in appendix (6C). In the model for Finland the results are as expected: the null of weak exogeneity is rejected for all the variables, at least at a 10 per cent significance level. For the Swedish data the weak exogeneity assumption for the exchange rate is likewise as expected. Also the production costs were found to be weakly exogenous, indicating there are no exchange rate induced effects on input costs, or any feedback effects from export prices to costs.. The result that competitors' prices are weakly exogenous is however quite surprising, as Sweden has traditionally had a rather dominant position at the German sawnwood market. However, Mutanen (2006) suggested that the price of Finnish sawnwood has Granger-caused the price of Swedish sawnwood in the German market, so that Finland could be regarded as the price leader. This could have affected the result obtained. The weak exogeneity restriction of competitors' prices will be examined more thoroughly in parallel with formulation of the final model structure.

After formulation of the conditional VAR models, identification of the individual relations is conducted. The single cointegration relation in the model for Finland was identified as the sawnwood demand equation by applying the constant market share (CMS) assumption, that is, by setting the coefficient of competing exports, x_{FG}, to -1 (β_{41} = -1). Identification of the sawnwood price relation in the model for Sweden was done beforehand by simply excluding the variables of export quantities from the VAR model. Next, the structure of long-run relations is obtained i.e. by placing economically meaningful restrictions on the identified cointegration relations.

The maximum likelihood estimates (MLE) of these structural hypotheses (I-II) are presented in table (5.13). The homogeneity restriction required by economic theory was the first testable structure (I) in both models. As production costs are assumed not to have a direct effect on export demand, the sawnwood price variables, p_{FG} and p_{CG}, were accordingly set equal, in opposite signs ($-\beta_{21} = \beta_{31}$), in the sawnwood demand relation for Finland. The homogeneity assumption on the sawnwood price relation for Sweden was, in contrast, appointed by equating er_{SG} and p_{CG} ($\beta_{21} = \beta_{41}$) and by setting c_S equal to the difference of p_{SG} and er_{SG} ($\beta_{31} = -(\beta_{11} + \beta_{21})$). Thus, both relations are assumed homogenous of degree one in the nominal variables.

Table 5.13 LR tests of structural hypotheses on models for the German market under $r = 1$. Estimation samples 1995:1–2008:4/2006:2.

Finland - Germany		
Variables/ LR-test	(I) Long-run homogeneity	(II) B(1,2) ≠ -B(1,3)
	β_{i1}	β_{i1}
x_{FG}	1.00	1.00
p_{FG}	0.36	2.75
p_{CG}	-0.36	-0.28
x_{CG}	-1.00	-1.00
LR	χ^2 = 37.59*	χ^2 = 2.07
Prob.	0.00	0.15

Sweden - Germany		
Variables/ LR-test	(I) Long-run homogeneity	(II) Mark-up pricing
	β_{i1}	β_{i1}
p_{SG}	1.00	1.00
er_{SG}	-0.84	-1.00
c_S	-0.16	0.00
p_{CG}	-0.84	-1.00
LR	χ^2 = 4.56	χ^2 = 5.00
Prob.	0.47	0.54

Notes: 1) * denotes rejection of the restricted model system at 5 % level.
2) β_{i1} corresponds to export demand (x_{FG}) relation for the model of Finland and on domestic price (p_{SG}) relation for the model of Sweden.

The results indicate a rejection of the homogeneity structure (I) in the model for Finland. On ground of the unrestricted VAR model's structure, this was expected. When the homogeneity restriction was relaxed from the export demand relation ($\beta_{21} \neq \beta_{31}$, the model structure (II) could not be rejected anymore. Though, in absence of the homogeneity requirement, the model is not supported by economic theory and therefore interpretation of its coefficients is problematic. A fairly high magnitude of the price elasticity (-2.75) was, nevertheless, as expected based on visual inspection of the data and could therefore be conceived as supporting information.

The homogeneity structure for the model of Sweden is strongly identified in the empirical sense, and moreover, magnitude of the exchange rate pass-through (0.16) is in the range of what was expected. Weak exogeneity of competitors' prices could not be rejected in the restricted model either, implying that it should be included in the final model structure. As the price relation does not resemble a mark-up pricing strategy, a zero pass-through hypothesis (II) was tested. The likelihood of the model increased rather much, implying only little effects of exchange rate fluctuations on export prices in the German market. Though as already expressed, there seems to have occured a change in pricing strategy from 2006 onwards. Extending the observation period until the end of 2008, consequently increased the exchange rate pass-through coefficient rather much (Appendix 6D). The overall model structure could then be rejected so that validity of the coefficients is questionable.

6. SUMMARY AND DISCUSSION

6.1 Summary of the findings

The results of the empirical study revealed the responsiveness of trade flows to exchange rate changes. This was conducted by examining the long-run relationship of exchange rate variation and price determination for sawnwood exporters from Finland and Sweden to markets in the UK and Germany. The following chapter will first summarize the results obtained from the empirical estimation and further examine them in reflection to previous similar studies. Throughout the chapter, specific attention will be given to the effects of EMU participation and its implications on the competitiveness of Finnish sawnwood exporters. Moreover, synthesis will be built between the separate import markets for identifying possible similarities and/or differences in pricing strategies among exports to an EMU and non-EMU region. The chapter is concluded with a discussion about the robustness as well as the generalizability of the findings. This will encompass the possible problems and limitations of the study.

6.1.1 Finnish long-run price determination

The results give evidence for the existence of imperfect, rather than perfect, competition between the competing suppliers in sawnwood markets. For Finland, the estimated partial and total long-run ERPT coefficients between 0.60 and 0.70 in the UK market would indicate that over half of an exchange rate change is shifted into the export price denominated in pounds sterling and the rest is absorbed by the exporters' variable mark-up. The signs and magnitudes of the own-price (-2.38) and exchange rate (2.38) elasticities of Finnish sawnwood demand are consistent with the economic theory and further support the finding that export quantities are sensitive to exchange rate and price fluctuations. For the period of depreciation the results indicate that Finnish exporters have been able to increase price competitiveness by lowering the export price and thus being able to maintain or even increase market share. The appreciation of the euro against the British pound has, on the other hand, meant reduction in price competitiveness and possibly loss of market share. In the German market, magnitude of the price elasticity of demand (-2.75) also implies high responsiveness of export demand to price movements. Rejection of the homogeneity assumption from the theoretical model, yet, lowers the validity of this finding.

These implications are derived assuming *ceteris paribus* condition for the exporting country. However, as has already been remarked, in order to measure the true impact of currency changes more properly one must also take notice of how the competitors' currencies have developed and what their corresponding pricing strategies have been. In the present study, this approach was restricted into studying Finnish sawnwood exporters' most important competitor Sweden. This would further give information on what the effects have been regarding Finland's participation in the monetary union, especially on intra-EMU trade in which exchange rate change induced measures to improve price competitiveness have been eliminated.

6.1.2 Swedish long-run price determination

Although the ERPT estimates for Sweden are of lower magnitude than for Finland, there is still evidence of market imperfections. A noticeable thing is that the exchange rate pass-through for Sweden in both the UK and German markets are of same level. This indicates that the sawnwood exporters charge relatively the same prices, in response to exchange rate fluctuations, in both destinations. According to Seo (2006), the implication of this is evidence of no pricing-to-market behavior, even though the pass-through of exchange rate changes is incomplete.

In both import markets, the exchange rate pass-through lies around 15% and 25%, so that most of the exchange rate change is absorbed into profit margins and only a small portion is shifted into destination currency export prices. Accordingly, weakening of the pound sterling against both currencies has meant that Finnish exporters' price has been raising relatively more in the UK market, resulting in loss of market share. The appreciation of the pound sterling in the beginning of the observation period has, in turn, implied increased price competitiveness and export quantities for Finnish sawnwood exporters. Thus, as the pricing strategies seem to differ between Finnish and Swedish sawnwood exporters, also the implications are opposite even in the case of parallel exchange rate developments. The signs of own-price (-0.93) and exchange rate (0.93) elasticities of demand are again consistent with the underlying trade theory and supported by the lower ERPT estimate. Moreover, lower magnitude of the demand elasticities would imply lower product substitution, which could mean that krone depreciations are not even worth using exclusively for price decreases; demand can be kept fairly stable together with higher profit margins. The lower product substitution could be due to better marketing measures of Swedish sawnwood exporters for example through supplementary services included with the core product.

The situation is the same in the German market. A devaluation of the krone against the euro seems not to have increased price competitiveness of Swedish sawnwood exporters by the full amount. This could be seen as a positive sign for Finnish sawnwood exporters considering the impact of EMU participation, because a weak krone against the euro has been regarded as the most problematic situation price competetiveness-wise. Nevertheless, in addition to an advantage gained by slightly lower relative prices, Swedish sawnwood exporters have been able to increase their profit margins along with krone depreciations. This has and will presumably continue to give an advantage for them in the longer run.

6.1.3 Short-run exchange rate effects

The short-run exchange rate pass-through i.e. the nominal price rigidity was tested with a hypothesis of weak exogeneity on the exchange rate adjustment coefficients. In none of the models this restriction could be rejected, implying that prices are indeed rather sticky in the short run. Therefore, a local currency pricing strategy could be assumed to exist for both exporters in both markets. This is supported by several studies. For example, the results of a survey study conducted by Friberg and Wilander (2008) support this inference by revealing that as a consequence of bargaining between exporters and importers, Swedish exporters mainly choose the currency of the customer. Friberg and Vredin (1996) remark, that in the wood industry the British pound has traditionally been an important invoicing currency. This would indicate that at least a large portion of the exports to the UK are invoiced in pounds. Brissimis and Kosma (2005) and Faruquee (2004) have studied the choice of invoicing currency to import prices in the euro area and found that prices are predetermined in the short run. Thus, the use of euros in exports to Germany is well justified as well.

Kamps (2006) has, on the other hand, documented the overall increasing role of the euro in transaction payments. In Finnish sawnwood exports to the UK, it is hence presumable that the euro is used in parallel with the British pound as an invoicing currency. Yet, as Swedish sawnwood exporters are assumed to invoice mostly in pounds in exports to the UK, this same behaviour could be expected from the majority of Finnish sawnwood exporters. As mentioned, when the forward currency markets are introduced it is often optimal to invoice in the buyer's currency and fully hedge the exchange rate risk. For example UPM-Kymmene has reported large amounts of hedging against the pound sterling in 2007 and 2008 (UPM Annual Report 2008, p. 88).

6.2 Previous studies

A common finding from previous studies has been that the ERPT is lower for paper industry products than for wood industry products. For example Hänninen (1998a) found that the ERPT of Finnish sawnwood export prices to the UK were close to unity (92%). Uusivuori and Buongiorno (1991) have estimated price determination for US exports in several forest product categories and found that lumber exports to Japan had also fairly high ERPTs; between 79% and 104%, depending on the species. Moreover, Bolkesjø and Buongiorno (2006) found that the long-run ERPT has been close to unity (90%) in exports of coniferous sawnwood from USA to its main markets. In a study by Hänninen and Toppinen (1999), the exchange rate pass-through of Finnish newsprint and pulp prices were, in contrast, found to be much lower in exports to the UK and Germany; for newprints around 46% and 60% and for pulp between 7% and 68%. Also Menon (1993a) has estimated a higher ERPT for Australian imports of wood products (80%) than for paper products (45%). Hänninen (1998b p. 29 - 30) still reminds that, because of the scarcity of the results, conclusions about differences in the competitive environments of wood and paper industries are difficult to draw based solely on obtained pass-through estimates.

Another general finding from previous studies has been that exports to USA are less sensitive to exchange rate changes than exports to Europe. This has been explained by larger domestic production in USA than in Europe, and thus lower market power of exporting firms. For example in a study by Vesala (1992), the ERPT of Finnish paper products was found to lie between 66% and 69% for Western Europe, and for USA between 16% and 30%. The results of the study by Bolkesjø and Buongiorno (2006) indicated also low exchange rate pass-through for sawnwood prices on US imports from Canada. Also Alavalapati et al. (1997) found in their study that the ERPT of Canadian pulp price was relatively small in exports to the US.

Based on earlier models for Finnish sawnwood exports to the UK, the relatively large ERPT rate obtained in the present study could be expected. The magnitude of the own-price elasticity is in the range of earlier estimated results: Hänninen (1994) found the own-price elasticity to be -1.71 estimating from annual data (1976 – 1990), Hänninen (1998a) estimated an elasticity of -2.44 from quarterly data (1978 – 1994) and Tervo et al. (1988), -3.1, with Almon polynomials from quarterly data (1966 – 1985). In spite of the fairly high pass-through estimate, the magnitude was still approximately 20% - 30% lower than obtained by Hänninen (1998a) for the period before joining the EMU. This could be seen as a transition to a more competitive environment in sawnwood trade. Devereux et al. (2004) conclude in their study that the more stable the monetary policy the lower will also be the relative pass-through rates. Therefore, the more unstable monetary policy experienced in the late 1980's and early 1990's, caused by several currency realignments of the Finnish mark, could have generated a greater pass-through rate. Now, with a more reliable monetary policy by the European Central Bank (ECB), the exchange rate has been more stable which in effect could have been reflected in a more conservative pricing strategy of exporting firms.

For Sweden, reference studies concerning price determination of exported sawnwood are scanty. Of the few studies that could be found on the subject, two of them have estimated own-price and cross-price elasticities in the UK and German sanwood markets (Hänninen 1994; Mutanen 2006) and the third has tested the inference of the law of one price in the UK sawnwood market. The study conducted by Hänninen (1994), examined own-price and substitution elasticities in the demand of the UK sawnwood imports for the period 1961 - 1990. As the own-price elasticity for Sweden (-0.69) was of much lower magnitude than for Finland, a lower ERPT rate could be expected accordingly. Moreover, the result is well in line with the own-price elasticity estimate obtained from the present study (-0.93). Own price-elasticity of Swedish sawnwood was estimated for the German market by Mutanen (2006) for different sub-periods between 1991 and 2003. He found that the price elasticity of Swedish sawnwood varied between 0.3 and 0.4 depending on the time period chosen.

This would indicate again lower exchange rate pass-through, which would be in accordance with the low rate obtained from the empirical estimation of this study. Another study by Hänninen (1998d) indicated a rejection of the LOP assumption between the Finnish and Swedish sawnwood in the UK market, which could be due to differing pricing strategies regarding an exchange rate change.

Apart from the aforementioned studies, a large part of the undergone studies examines exchange rate pass-through to Swedish import prices rather than export prices and, in addition, to non-forest products. Nevertheless, some studies have been undertaken regarding exports of paper products. Pricing-to-market studies of Swedish exports by Alexius and Vredin (1999) and Friberg and Vredin (1996) have proved, on the one hand, that relative export prices of various paper and paperboard products are correlated with exchange rates, indicating incomplete exchange rate pass-through. On the other hand, Adolfson (2001) found local currency prices in the German and the UK kraft paper markets to be rather invariant to movements in the exchange rate of the Swedish krone, with pass-throughs of only 18% and 29% in the respective markets. Interestingly, these estimates are at the same level as what was obtained in the present study for sawnwood exports to the same destination markets. As kraft paper can be regarded a homogeneous product like sawnwood, the findings support the estimation results of the present study. On the contrary, for exports of more heterogeneous products (e.g automobiles) the estimated pass-through rates have been found to be much higher (Adolfson 2001, Athukorala and Menon 1995).

As pointed out, there seem to be no evident differences in Swedish exporters' pricing strategies between sawnwood trade to an EMU or a non-EMU customer. This is in accordance with a common statement from studies concerning exports from non-euro areas to euro areas i.e. there is no evidence in favor of the assumption that the adoption of the euro has caused a structural break in the pricing behavior of the exporters to the euro area (e.g. Campa and Minguez 2006). Similarly, studies (e.g. Smith 2009) concerning the predictive value of pre-Euro data on post-Euro forecasts have found no indications of structural changes regarding the foundation of the EMU. Furthermore, a general finding has been that the degree of exchange rate pass-through to import prices in the euro area is rather low (e.g. Brissimis and Kosma 2005). These findings clearly support the result that Swedish sawnwood exporters' pricing strategy is rather independent of the trading partner, and no identifiable structural breaks have occurred from the foundation of the EMU.

The obtained results for Sweden are apparently in many ways in accorcande with results of earlier studies. Yet, there are some contradictory findings as well. The results are for example not in line with the findings that, in general, sawnwood products tend to have larger ERPT rates than paper products. In contrast, Swedish exporters seem to follow the same pricing strategy in both, wood and paper, industries as the obtained pass-through coefficient from the present study for sawnwood is in the range what has been estimated for paper products in previous studies (Adolfson 2001). As a consequence, Finnish and Swedish sawnwood exporters follow somewhat opposite pricing strategies. However, Mutanen (2006) concludes that at least in the German sawnwood market, imports originating from Finland and Sweden are virtually the same product hence indicating an integrated market. Of course, even in practical business situations things such as a dominating market share, established long-term customer relationships, marketing measures, service entities etc. can have an effect on the distinctive pricing strategies.

6.3 Robustness of the results

For Finnish sawnwood exports, the theoretical system structure for identifying total pass-through of exchange rate changes seems to be working quite well. It could not be rejected for exports to the UK and, additionally, the results are at least to some extent parallel with previous estimations. The partial pass-through estimation results are also of the same level, indicating that the estimated pass-through is fairly robust to the model structure. However, as the size and the spread of eigenvalues in the multi-equation system seem to suggest more than one cointegration vector i.e. an export demand relation in addition to a price relation, the total pass-through captures more thoroughly the effect of an exchange rate change. Rao (1994, p. 22) also points out that other things being equal, it is desirable for an economic system to be stationary in as many directions as possible. That is, the more cointegration vectors there are, the "more stable" the system is.

Some ambiguity still remains in interpreting the results of the Finnish system structure, due to the rejection of the constant market share assumption on the demand relation. One way of eliminating this problem could have been to explain sawnwood demand by total imports instead of imports from only competitors. Hetemäki et al. (2004) have for example found total imports to be a good indicator for demand of Finnish sawnwood in the German market. None of the misspecification tests, except normality of residuals in the model for German imports, proved to be significant at the conventional 5 per cent level. This further supports that the models are well specified and approximate well the data generating process.

On the contrary, the theoretical model systems for Swedish sawnwood exports do not seem to fit so well the multi-equation model structure, although according to magnitudes of the eigenvalues there is strong evidence of more than one cointegrating relation in the data sets for both import markets. Truly, the linear restrictions driven from the underlying theory could be rejected in each of the model systems with large confidence levels (*p*-values). The system representing sawnwood exports to the German market was chosen not be presented in the study as the coefficients did not have any statistical significance nor scientific meaning whatsoever. In contrast, the long-run coefficients in the system for the UK market had the right signs and overall the magnitudes appear more reliable. Still, the constant market share restriction was rejected and the adjustment coefficients for the variables representing domestic and competing quantities received suspiciously high values. This could imply that the demand relation for Swedish sawnwood exports is misspecified, causing the export demand vector to not be cointegrated in its true meaning i.e. it does not contain any long-run information. In order to safeguard for any misspecification errors, modifications to the model should be tested.

Misspecification tests did not indicate any problems in the system structures. However, autocorrelation and heteroskedasticity appear to be problems in the Swedish single-equation model for the UK market hence implying that the robustness of the partial pass-through estimate can not be justified. None of the diagnostic misspecification tests on the residuals are significant in the model for the German market, so that the results appear more reliable. The fact that the observation period was needed to be shortened could, though, decrease the predictive value of the estimated relationships. Extending the observation period raised the pass-through coefficient and lowered the likelihood of the model, so that the overall model structure could then be rejected. This could entail a structural break in the data i.e. a change in pricing strategy of Swedish sawnwood exporters for example due to tightening competition in the German market together with a favourable exchange rate development. In the scope of this study, testing of any structural changes was, however, chosen not to be conducted. Shortness of the remaining sub-samples could have also biased the results.

Overall, the estimated models had the expected signs and magnitudes followed previous studies, so that a meaningful economic interpretation could be made. Still, it can be argued that for example lag determination is somewhat arbitrary, and the results may differ depending on the lag length. A drawback in the study, which was not examined and could influence the estimation results, relates to ERPT asymmetry i.e. that the pricing strategy might be different depending on whether the currency is depreciating or appreciating (e.g. Uusivuori and Buongiorno 1991). Omission of the asymmetry-effect could then, either under- or overestimate the pass-through coefficient and thus lead to false interpretations. Also using aggregate data for the sawnwood product could cause bias to the product homogeneity assumption, if the exported quality categories differ greatly between the competing exporters.

Finally, a limitation of the estimation method is stemming from the fact that the critical values of the likelihood ratio tests for the linear restrictions are based on asymptotic χ^2 distributions. Given that simulated empirical critical values are typically larger, there is a tendency to reject the null hypothesis too often. For a small sample, the asymptotic distribution is then a poor approximation. This is even more true considering that the systems consist of relatively many estimated parameters, resulting from various variables and several cointegration vectors, compared to a rather short time span. The partial pass-through estimations could be, in this sense, seen as more reliable. The main point still stands, that the inference based on the asymptotic distributions could be weak and the results should be interpreted with this in mind. (Adolfson 2001)

7. CONCLUSIONS

The business environment for many sawnwood producers originating from the more traditional forest industry countries, such as Finland, has changed in many ways in the last decade or so. Not the least has been the effect of new producers waving from low-cost countries, further tightening the competition for global market shares. In some sense, an even greater change has been set off by the foundation of the European Monetary Union in 1999. The inference is driven from the major role currency realignments played in Finnish forest products trade in the past. Nowadays, this source cannot be used anymore as a measure to "artificially" stabilize external shocks faced by the economy, forcing many firms to draw back and search for ways to adapt to the new situation. Additional interest has brought the fact that Finland's main competitor in forest products trade, Sweden, has remained the independency of its monetary policy and could in theory still fix the value of the krone. Another serious consideration has been brought about by the weakening of the krone and strengthening of the euro for the past few years, which could have raised Swedish exporters' price competitiveness. Undoubtedly, this negative reverse development of currencies, experienced by Finnish exporters with the most important competitors, would have precipitated devaluation pressures at the era of the Finnish mark.

This study was aimed on evaluating the above mentioned effects of Finland's EMU participation on Finnish sawnwood industry's price competitiveness. This was carried out by studying exchange rate pass-through (ERPT) of Finnish and Swedish sawnwood prices in the UK and Germany. The emphasis was essentially on long-run effects, as this would catch the strategic pricing induced by exchange rate fluctuations. The model specification was based on the theoretical presumption of a small open economy, where exporters are price takers and relative prices of competitors determine the exported quantities from each country of origin. The results are somewhat contrasted with this assumption, appearing more consistent with price discrimination and some degree of market power of exporting firms.

The estimated ERPT coefficients indicate that Finnish exports have been affected to a great extent by currency movements in the UK market. Depreciations experienced in the first half of the observation period have boosted export demand, whereas appreciations in the second half have, in turn, dampened imports from Finland to the

UK. This result is in line with previous estimations (e.g. Hänninen 1998a). The pricing strategy exploited by Swedish exporters has been somewhat opposite to Finnish exporters' although the developments of the respective currencies have been fairly parallel for the whole observation period. This has meant both a more stable Swedish sawnwood price for importers in the UK and export demand faced by Swedish exporters. The results give little indication of any pricing-to-market behavior, as the magnitude of pass-through has been of the same level in the German market as well. This would further suggest that the rather heavy depreciation of the krone against the euro has not affected negatively Finnish exports to Germany, at least not by the full amount. Still, Swedish producers have been able to achieve higher profits, which appears to have been the main consideration behind some recent shifts of production from Finland to Sweden.

The implication of this study is that the realization of the third stage of EMU in 1999 seems not to have been a major determinant of Finnish sawnwood producers' competitiveness in international markets. Changes in market conditions, for example through the overall decrease of German sawnwood imports, increased supply from Eastern European and Asian countries, worldwide dampening of housing demand, technological advances etc. could be considered as more important factors affecting the recent development of Finnish sawnwood exports. Now, the emphasiss is again more on the determinants of long-run competitiveness e.g. through price elasticities of production inputs and overall production efficiency. Toivonen et al. (2005) have also emphasized the importance of product quality, especially intangible components of the product, under these market conditions. They suggested that sawnwood suppliers from Finland could greatly improve their competitive position by enhancing their service, logistics and other dimensions of the intangible product offering.

Forest industry companies are nowadays multinational corporations having production capacity across borders, so that production can be shifted to where it is most profitable. Gron and Swenson (1996) have suggested that under these circumstances firms' export prices are unlikely to change one-for-one with exchange rate fluctuations. This could, in turn, affect the generalizability of the estimation results. An advance to the present study would then be researching pricing strategies on the company level. Additionally, this would enable comparisons between companies of different size and scope of trade. Further research would be needed similarly for different forest product categories and markets as well as the inspection of possible asymmetries in pricing strategies. Also, studying short-run dynamics of exchange rate changes could give further insight to export price determination for example through the choice of invoicing currency. Finally, in forthcoming studies the observation period can be restricted to account solely the EMU-period. This would give a more comprehensive view of joining the monetary union alone, which could in the present case still not be fully achieved.

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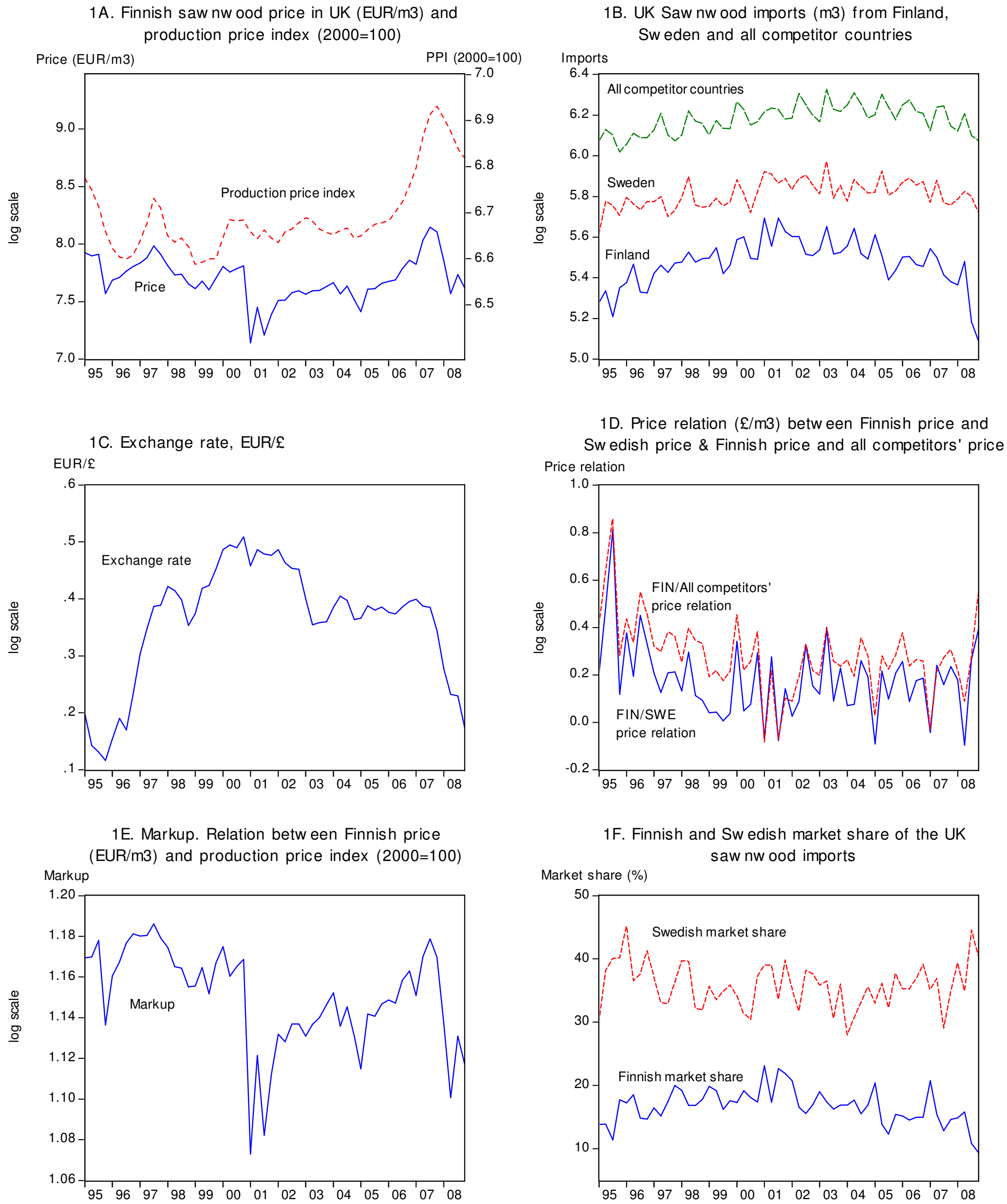
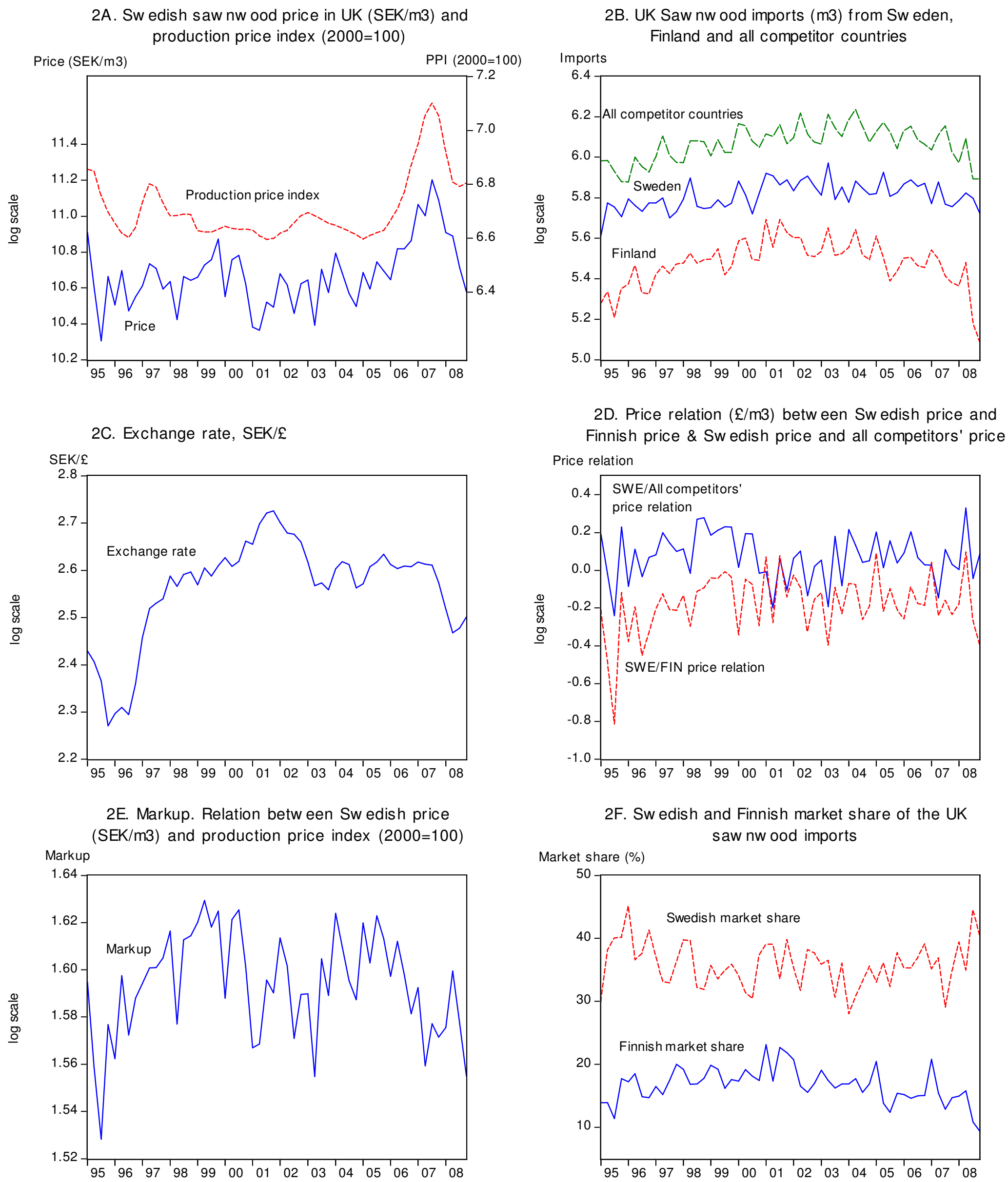
APPENDICES

Appendix 1 Quarterly time series data for UK imports from Finland covering period 1995 – 2008.



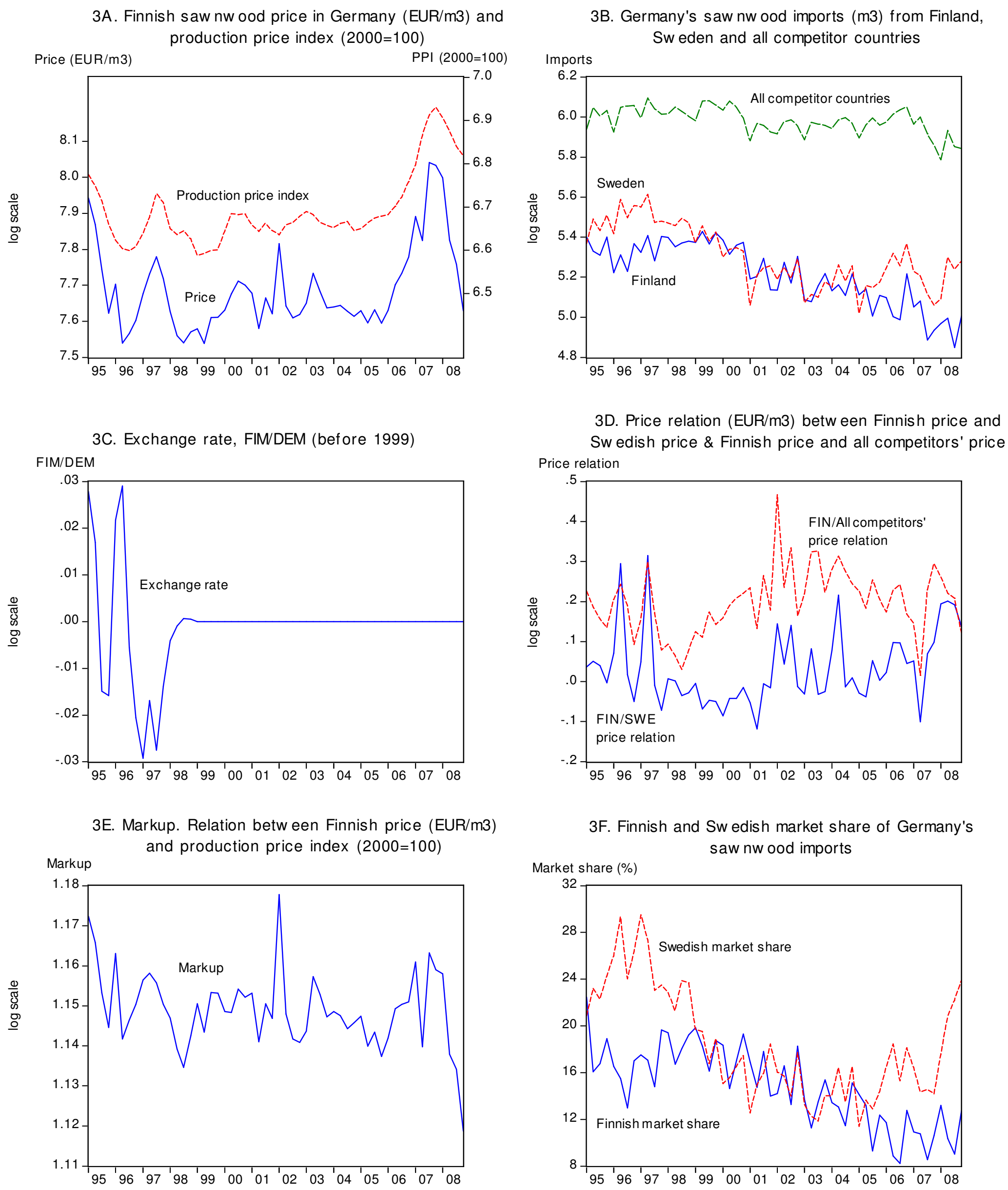
Sources: ETLA; Eurostat

Appendix 2 Quarterly time series data for UK imports from Sweden covering period 1995 – 2008.



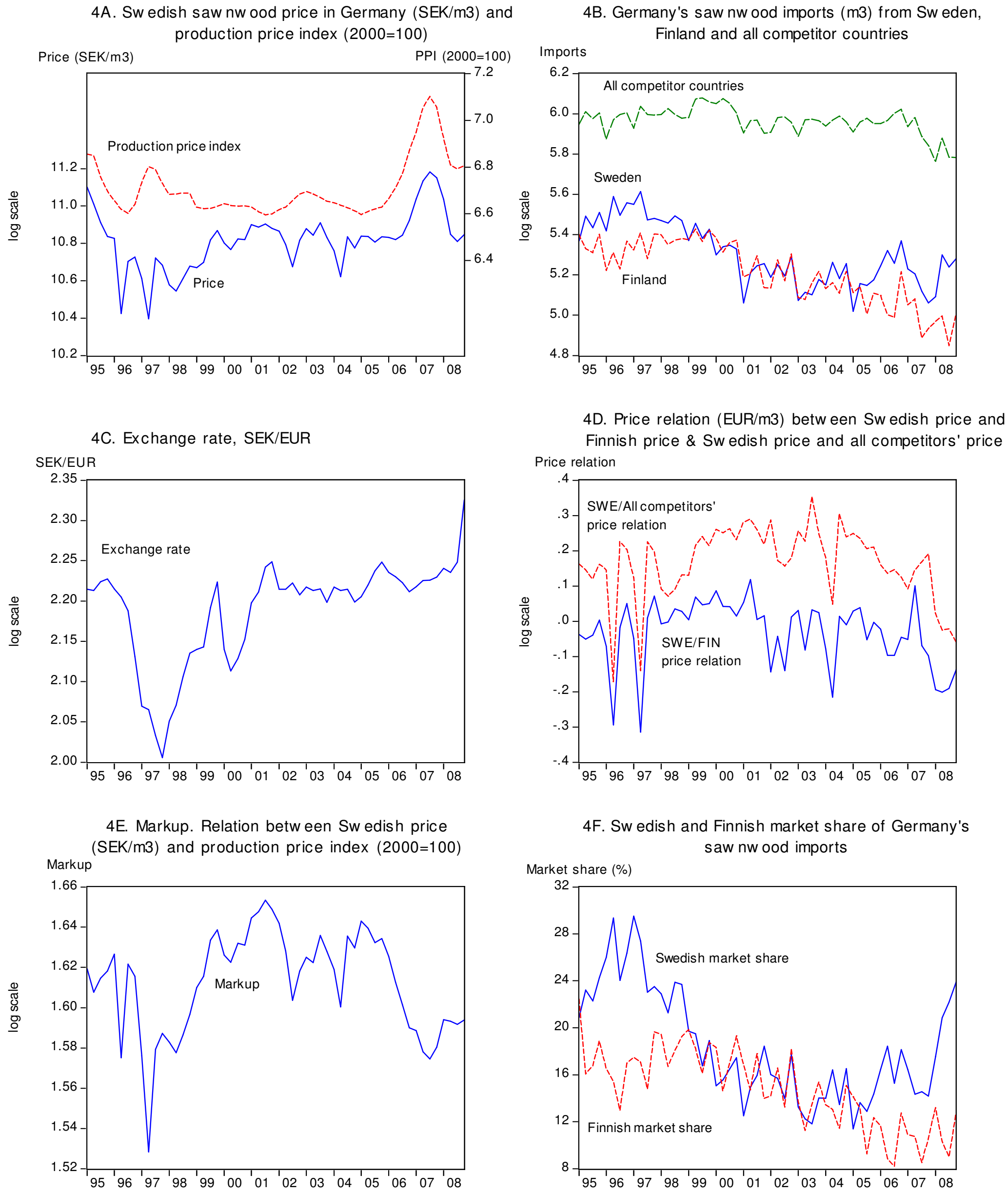
Sources: Riksbank; Eurostat

Appendix 3 Quarterly time series data for German imports from Finland covering period 1995 – 2008.



Sources: ETLA; Eurostat

Appendix 4 Quarterly time series data for German imports from Sweden covering period 1995 – 2008.



Sources: Riksbank; Eurostat

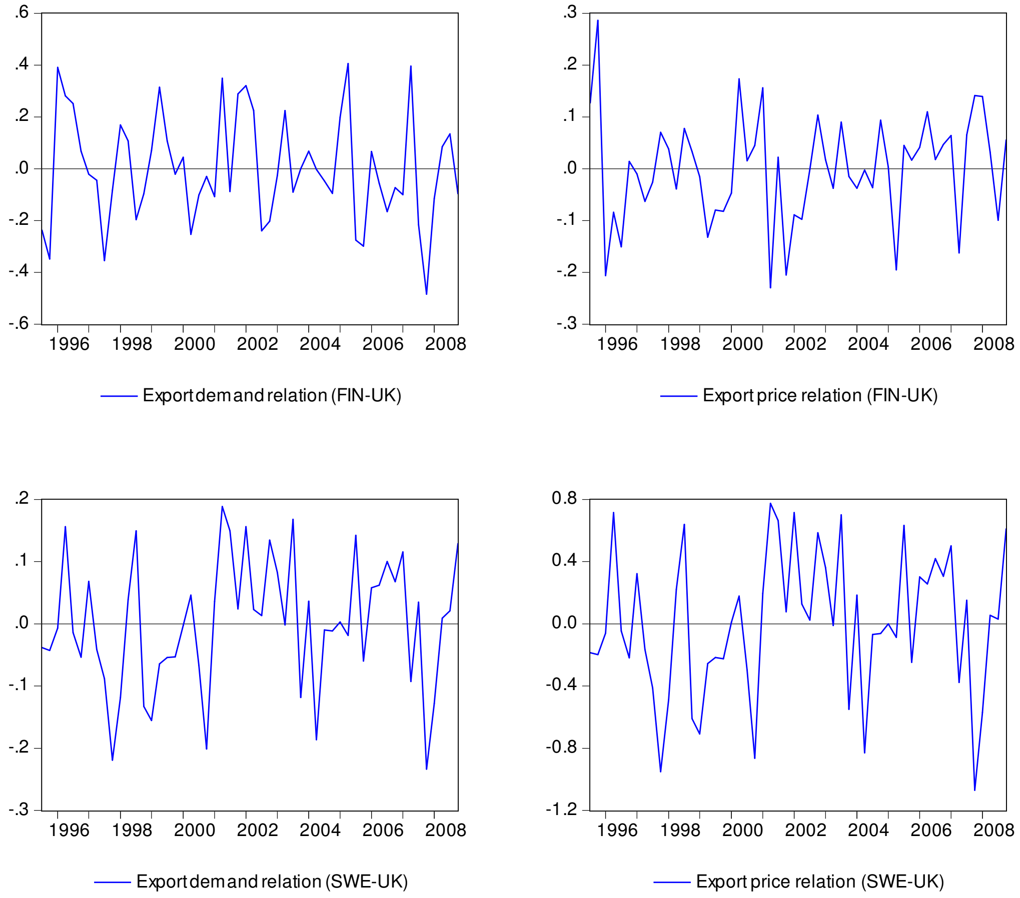
Appendix 5A Cointegration rank tests of unrestricted VAR models for the UK market under p = 6. Estimation samples 1995:1–2008:4.

	Finland - UK					
Data trend	Linear			Linear		
Test Type	Intercept (C), No trend			Intercept (C), Trend (T)		
Null hypothesis $H_0 = r \leq i$	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**
None	0.53	0.00*	0.03*	0.69	0.00*	0.00*
At most 1	0.40	0.02*	0.23	0.51	0.00*	0.04*
At most 2	0.32	0.04*	0.24	0.39	0.03*	0.16
At most 3	0.26	0.11	0.18	0.31	0.10	0.22
At most 4	0.15	0.29	0.26	0.19	0.28	0.41
At most 5	0.01	0.47	0.47	0.12	0.35	0.35

	Sweden - UK					
Data trend	Linear			Linear		
Test Type	Intercept (C), No trend			Intercept (C), Trend (T)		
Null hypothesis $H_0 = r \leq i$	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**
None	0.65	0.00*	0.00*	0.67	0.00*	0.00*
At most 1	0.48	0.00*	0.03*	0.58	0.01*	0.00*
At most 2	0.31	0.07	0.32	0.33	0.37	0.50
At most 3	0.22	0.13	0.35	0.24	0.55	0.65
At most 4	0.14	0.16	0.31	0.17	0.63	0.58
At most 5	0.05	0.07	0.08	0.07	0.74	0.74

Notes: 1) P-values by MacKinnon-Haug-Michelis (1999).
2) * denotes rejection of the hypothesis at 5% level.

Appendix 5B Cointegration relations in the UK market under r = 2. Estimation samples 1995:1–2008:4.



Appendix 5C LR tests of weak exogeneity on models for the UK market. Estimation samples 1995:1–2008:4.

	Δx_i	Δp_i	Δer_i	Δc_i	Δp_o	Δx_o
			Finland - UK			
LR	9.33*	24.32*	3.52	8.50*	9.72*	19.89*
Prob.	0.02	0.00	0.31	0.03	0.02	0.00
			Sweden - UK			
LR	12.70*	7.31*	0.59	22.59*	8.24*	13.89*
Prob.	0.00	0.02	0.74	0.00	0.01	0.00

Note: * indicates rejection of the weak exogeneity restriction at 5% level.

Appendix 5D Lag order determination of unrestricted VAR models for the UK market under p = 4. Estimation samples 1995:1–2008:4.

	Lag (k)	LR	SC	HQ	AIC
Finland - UK	0	NA	-9.11	-9.29	-9.41
	1	300.70	-14.55*	-15.12	-15.46
	2	36.60	-14.21	-15.15*	-15.73
	3	29.02*	-13.76	-15.08	-15.89*
	4	11.51	-12.88	-14.57	-15.61
	5	19.55	-12.32	-14.38	-15.65

	Lag (k)	LR	SC	HQ	AIC
Sweden - UK	0	NA	-9.50	-9.68	-9.80
	1	216.73	-13.08*	-13.64	-13.99
	2	45.98	-12.97	-13.90	-14.48
	3	36.87*	-12.73	-14.04*	-14.85*
	4	18.12	-12.05	-13.73	-14.77
	5	13.14	-11.27	-13.33	-14.60

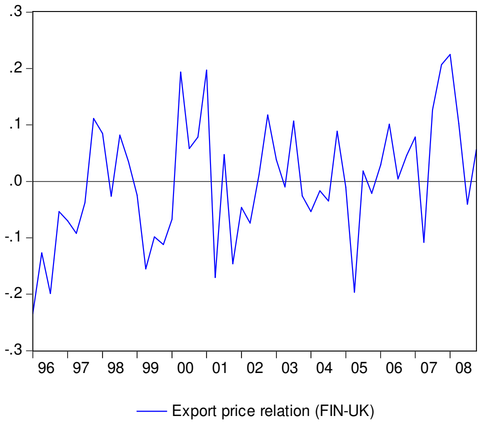
Notes: 1) * indicates lag order selected by the criterion at 5% level.
2) LR = sequential modified LR test statistic, SC = Schwarz information criterion, HQ = Hannan-Quinn information criterion and AIC = Akaike information criterion

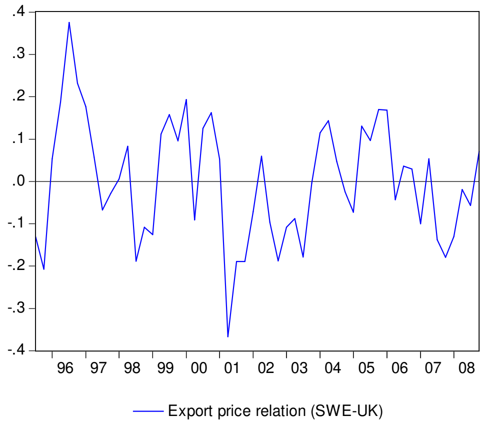
Appendix 5E Cointegration rank tests of unrestricted VAR models for the UK market under p = 4. Estimation samples 1995:1–2008:4.

	Finland - UK			Sweden - UK		
Data trend	Linear			Linear		
Test Type	Intercept (C), Trend (T)			Intercept (C), No trend		
Null hypothesis $H_0 = r \le i$	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**
None	0.43	0.01*	0.10	0.36	0.00*	0.12
At most 1	0.37	0.09	0.07	0.31	0.00*	0.06
At most 2	0.16	0.52	0.66	0.23	0.02*	0.04*
At most 3	0.11	0.44	0.44	0.06	0.06	0.06

Notes: 1) P-values by MacKinnon-Haug-Michelis (1999).
2) * denotes rejection of the hypothesis at 5% level.

Appendix 5F Cointegration relations in the UK market under $r = 1$. Estimation samples 1995:1–2008:4.





Appendix 5G Misspecification tests on models for the UK market under $r = 1$. Estimation samples 1995:1–2008:4.

	Autocorrelation	**Heteroskedasticity**	**Normality**	
	(LM)	(White)	(JB_{CHOL})	(JB_{URZ})
		Finland - UK		
Statistic	22.67*	293.87*	13.78*	55.63*
Prob.	0.12	0.15	0.09	0.45
		Sweden- UK		
Statistic	45.25	129.65	9.24*	54.38*
Prob.	0.00	0.00	0.32	0.50

Note: * denotes significance at 5% level.

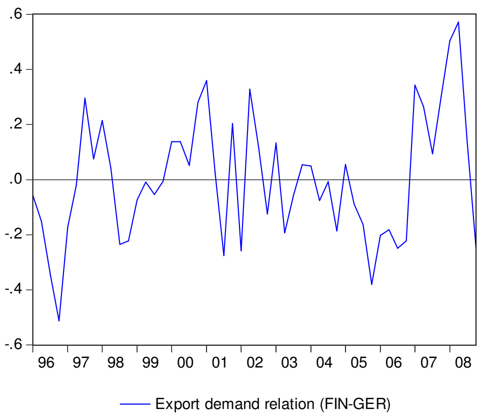
Appendix 6A Cointegration rank tests of unrestricted VAR models for the German market under $p = 4$. Estimation samples 1995:1–2008:4/2006:2.

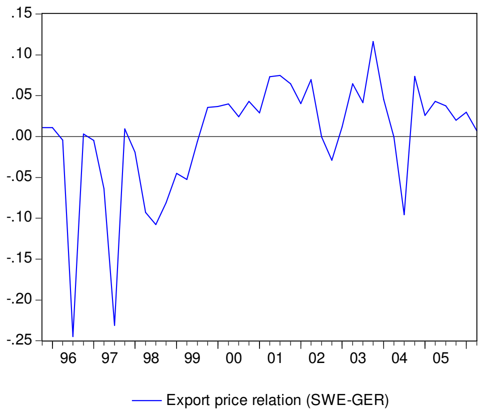
	Finland - Germany					
Data trend	Linear			Linear		
Test Type	Intercept (C), No trend			Intercept (C), Trend (T)		
Null hypothesis $H_0 = r \leq i$	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**
None	0.54	0.00*	0.00*	0.63	0.00*	0.00*
At most 1	0.30	0.07	0.07	0.29	0.46	0.33
At most 2	0.13	0.42	0.37	0.11	0.80	0.94
At most 3	0.01	0.56	0.56	0.10	0.49	0.49

	Sweden - Germany					
Data trend	Linear			Linear		
Test Type	Intercept (C), No trend			Intercept (C), Trend (T)		
Null hypothesis $H_0 = r \leq i$	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**	Eigenvalue λ_i	Trace test Prob.**	Max-Eigen Prob.**
None	0.40	0.02*	0.21	0.48	0.03*	0.12
At most 1	0.33	0.04*	0.13	0.39	0.15	0.14
At most 2	0.17	0.12	0.33	0.19	0.53	0.70
At most 3	0.09	0.04*	0.04*	0.13	0.41	0.41

Notes: 1) P-values by MacKinnon-Haug-Michelis (1999).
2) * denotes rejection of the hypothesis at 5% level.

Appendix 6B Cointegration relations in the German market under $r = 1$. Estimation samples 1995:1–2008:4/2006:2.





Appendix 6C LR tests of weak exogeneity on models for the German market. Estimation samples 1995:1–2008:4/2006:2.

	Finland - Germany			Sweden - Germany		
	Δp_{FG}	Δp_{CG}	Δx_{CG}	Δer_{SG}	Δc_{S}	Δp_{CG}
LR	2.95*	2.85*	19.62**	0.03	0.41	0.50
Prob.	0.08	0.09	0.00	0.86	0.52	0.48

Note: *(**) indicates rejection of the weak exogeneity restriction at 10% (5%) level.

Appendix 6D LR tests of structural hypotheses on Swedish model for the German market under $r = 1$. Estimation sample 1995:1–2008:4.

Sweden - Germany			
	(I)	(II)	
Variables/ LR-test	**Long-run homogeneity**	**Mark-up pricing (Zero)**	**(Unity)**
	β_{i1}	β_{i1}	β_{i1}
p_{SG}	1.00	1.00	1.00
er_{SG}	-0.61	-1.00	0.00
c_{S}	-0.39	0.00	-1.00
p_{CG}	-0.61	-1.00	0.00
LR	$\chi^2 = 13.45$	$\chi^2 = 16.12$	$\chi^2 = 15.85$
Prob.	0.02	0.01	0.01

Notes: 1) * denotes rejection of the restricted model system at 5 % level.
2) β_{i1} corresponds to domestic price (p_{SG}) relation